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SVIC NOTES

TRANSPORTATION VIBRATION

There are many reasons for testing to simulate common carrier transportation environment, but in spite of these, some tend to take these tests for granted. One reason why these tests are important is all equipment experiences common carrier transportation, mostly as secured cargo, at some stage of its life cycle. Another reason is that these tests can be early indicators of the structural integrity or the fragility of the equipment. If the equipment won't survive common carrier secured cargo transportation, will it be able to survive the dynamic environment when it is installed in its intended vehicle? Thus the most important reason is to ensure that it can be handled and transported without damage.

Transportation environmental tests should be designed to simulate the normal shock and vibration conditions that equipment will encounter during shipment. Each mode of transportation (truck, rail, air and sea) generates its own shock and vibration environment, but the maximum potential for damage due to shock, and the maximum potential for damage due to vibration, is different in each mode of common carrier transportation. Nevertheless, we still desire assurance that equipment can survive any mode of common carrier transportation, and this raises the following questions: Should environmental tests for simulating common carrier transportation be tailored? How should laboratory test requirements be set?

To answer the first question, test tailoring implies that the intended mode of common carrier transportation is known or can be specified in advance. This is rarely the case. However, one might still develop a test to simulate the air suspension trailer vibration environment, as opposed to simulating the more severe vibration environment of a trailer with a conventional suspension system. But what would happen to the equipment if it is shipped in such a trailer and the air suspension system fails enroute? This is one example of the risk one takes in tailoring transportation environment tests. In light of the previous discussion about transportability, I believe tailoring such tests is ill advised.

To answer the second question, measured shock and vibration data should be used to derive laboratory tests for simulating the transportation environment. A report by Ostrem and Godshal* summarizes data incident to the most severe transportation shock and vibration conditions, railroad car coupling and truck vibration respectively. The report also contains a plot summarizing vibration measurements made on trucks by three sets of investigators. There is reasonable agreement on the truck vibration environment below 20 Hz and this raises two questions. What are the effects of the high frequency vibrations on secured cargo? What is a realistic upper vibration test frequency? It will be necessary to answer both questions before realistic tests can ever be developed for simulating the transportation environment for secured cargo.

R.H.V.

*Ostrem, F.E. and Godshal, W.D., "An Assessment of the Common Carrier Shipping Environment," General Technical Report FPL 22, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI (1979).

EDITORS RATTLE SPACE

ENGINEERING EDUCATION WITH THE COMPUTER

The development and marketing of the personal computer have created a new fad in the United States. Even in these difficult times many personal computers are being used to perform menial mathematical tasks, store records, process words, and play games. People are interested in small computers. The schools have not been untouched by this mania. From elementary to graduate level educators are using computers as part of the educational process. It is not clear to me how the computer aids in this process -- except that the students master use of the computer itself.

A recent announcement that several colleges will require each engineering student to own a specific personal computer is indicative of the outlook of some faculty members. Although no reason was cited for this decision, college educators apparently believe that use of a computer will benefit the education of their students. My question is whether widespread use of the computer will be an aid to education or a distraction. I also wonder how the typical college graduate will benefit from computer training. Will such training be given in lieu of fundamentals? It has been said that there is no more room in the college curriculum for specialized subjects – in fact such communication skills as speech and writing have been sacrificed in the technical programs of many colleges and universities. Does this mean that the trend is continuing toward training engineers who find themselves buried in technical trivialities and unable to communicate with others.

On the positive side, however, I can envision that the personal computer will save students time in many design-oriented courses. Rather than waiting in line at computer centers the student will be able to perform computations at his own convenience. The student could even learn to use the computer on experiments – process control, data processing, and data display. The negative side of this computer availability is the tendency of many students and engineers to use the trial-and-error process in problem solution – the "throw it in and try it" syndrome.

Only time will tell whether this trend is an overreaction to the availability of powerful computational tools or will lead to a different type of engineering education. New applications of the computer in the engineering process will be of interest, however, because many of the engineering students working on computers will develop new computational techniques as well as new data storage and processing capabilities.

R.L.E.

DYNAMIC BALANCING WITH MICRO PROCESSORS

D.G. Stadelbauer*

***Abstract.** This article describes the use of micro processors in balancing.*

The nearly universal change from soft-bearing to hard-bearing balancing machines during the last 15 years was made economically feasible by the advent of transistorized and integrated circuitry, because hard-bearing machines require considerably more sophisticated filtering and amplification of the unbalance signal than the formerly prevalent soft-bearing machines.

Different approaches are used to measure the effects of unbalance in soft- and hard-bearing balancing machines. Soft-bearing machines measure unbalance in terms of vibration amplitude; hard-bearing machines measure in terms of centrifugal force. Force measurement provides the hard-bearing machine with the attractive feature of "permanent calibration." It is officially defined in ISO 1925 as "the property of a hard-bearing balancing machine that permits the machine to be calibrated once and for all and remain calibrated for any rotor within the capacity of the machine." Permanent calibration is accomplished by the manufacturer prior to shipment, so that the user only has to check it at periodic intervals.

Permanent calibration is useful with on-line computers because appropriately conditioned output signals from the balancing machine pickups represent a direct measure of the centrifugal force generated by unbalance. At a given balancing speed this force can be directly related to an unbalance; i.e., a certain mass at a certain radius. A given pickup voltage thus always means the same ounce•inch (or, gram•inch) unbalance in the bearing plane. The computer accurately calculates equivalent unbalances for any two arbitrarily selected correction planes; the slight inaccuracies that are usually present in analog plane separation devices are thus eliminated. The computer could also be used to account for the increase in centrifugal force proportionate to the square of the balancing speed. However, integrator circuits between balancing machine pickups and computer input provide constant unbalance readout over a wide speed range and suppress harmonics and extraneous noise signals.

Figure 1 shows a typical installation of a Hewlett Packard model HP 9845A in the control console of a balancing machine. The manual instrumentation with vectormeter readout above the HP 9845A furnishes part of the signal conditioning for the computer and also serves as a backup.

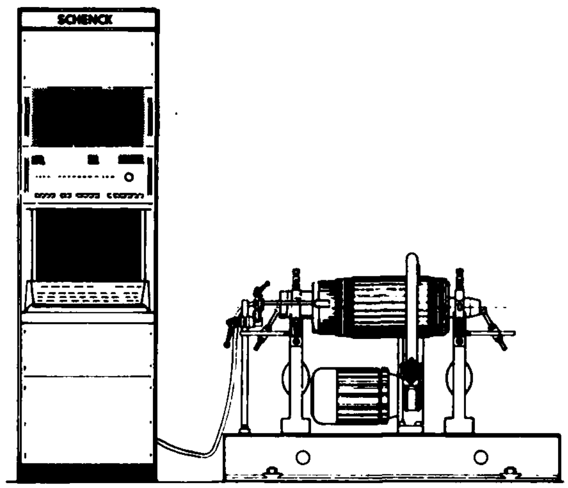

Figure 1. Hard-bearing Balancing Machine with Combination Computer and Standard Instrumentation

Because table top computers were not designed specifically for use on a balancing machine, many of their capabilities are wasted. Furthermore, the many keys sometimes confuse the operator and possibly do not provide the most foolproof way of using the

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balancing machine. In recognition of these shortcomings, balancing machine manufacturers have begun to develop their own micro processor-based instrumentation. One example is the CAB 500, marketed by Schenck Trebel Corp. and shown in Figure 2.

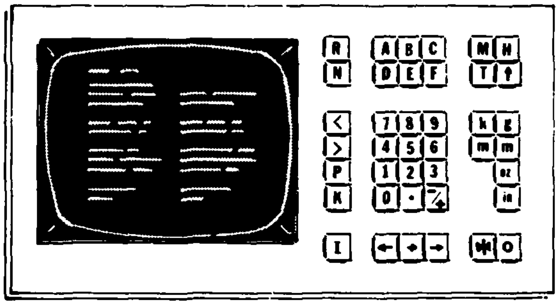

Figure 2. Micro Processor Instrumentation for Balancing Machine with Display Screen

Benefits of the CAB 500 include prompting of the operator with a CRT display, setup data storage in memory files for different rotor types, choice of unbalance correction methods in polar or component form, preselection of unbalance tolerance, and optional printout of data for a permanent record. The CAB 500 can be installed in the field to upgrade older hard-bearing machines.

Prompting guides the operator through the rotor data entry phase; the CAB 500 is thus easy to use. A curser always flashes at the next field at which data must be entered although such nonessential fields as the rotor code can be bypassed. Units for ABC or radius dimensions automatically go to inches and units for tolerances to gram•inches unless entered differently.

Preselection of the balance tolerance for each plane provides continuous comparison with the residual unbalance. After each run the operator is told if tolerance has been attained, thereby preventing unnecessary correction.

Indication of unbalance is provided in either English units, metric units, or a combination of the two (e.g., gram•inches). If unbalance is to be indicated and corrected in components, the total number of components can be individually selected for each plane. The reference angle of the first correction point in each plane can also be selected in case components are skewed, as they sometimes are on armatures or roots-type blowers.

Such built-in programs as error analysis routines facilitate troubleshooting and permit periodic verification of calibration with automatic recalibration if necessary. As with manual instrumentation the readout can be retained for an unlimited period of time and translated into other correction planes without running the rotor again.

Unbalance can be indicated in terms of dynamic unbalance or static/couple unbalance with digital or analog display. The latter is unique in that a vectormeter display is simulated on the CRT. Amount and angle of unbalance are indicated simultaneously by small targets surrounded by semicircles (Figure 3). This display shows a direct relationship of magnitude and position of unbalance in the two correction planes. On the right side of the display are stated the scale factor (maximum indication = 50g), exact unbalance data, and multiples of the tolerances represented by the readings.

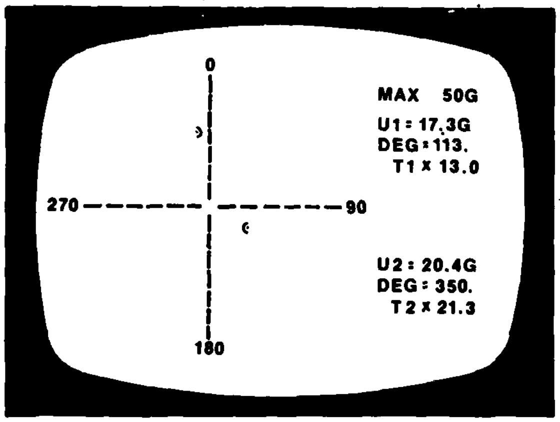

Figure 3. Simulated Vector Display of Unbalance

In the usual sequence of operation the display is used as shown in Figure 4. At this point all rotor data have been entered by the operator via the keyboard and the measuring run has been made; i.e., the rotor has been accelerated to balancing speed and unbalance readings have been taken.

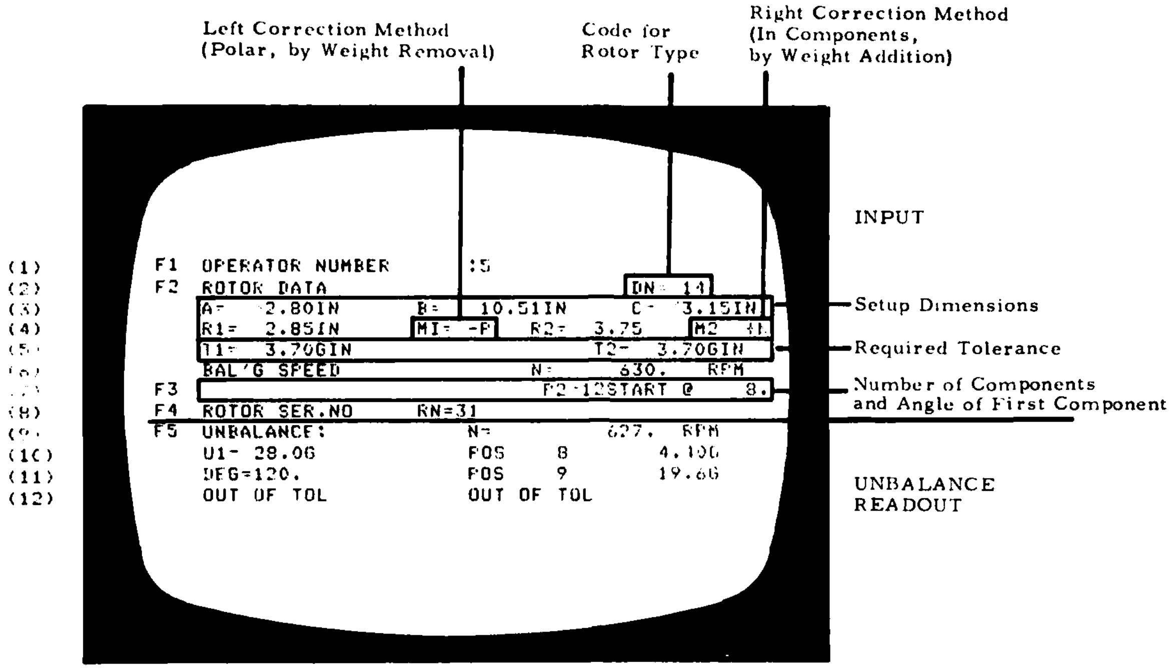

Figure 4. Setup and Unbalance Data

During the entry of the rotor data the operator is prompted by a moving curser. Appropriate keys on the keyboard permit control of the curser.

A detailed explanation of the display follows.

Line (1): F1 (Field 1) permits identification of the balancing machine operator.

Line (2): F2 ROTOR DATA is the heading for the entire Field 2 extending from line (2) to (7). Line (2) also permits identification of the rotor type, in this case No. 14.

Line (3): The A-B-C rotor dimensions as entered by the operator refer to dimensions illustrated in Figure 5.

Line (4): R1 refers to the radius in the left correction plane at which the unbalance is being measured. R2 refers to the right plane.

Also listed are the indication (or correction) methods M1 and M2; i.e., P for polar correction (single correction at the indicated angular position) in the left plane and K for component correction in the right plane. Component correction usually requires two corrections because the unbalance falls between two component positions. Plus or minus designations preceding P or K indicate that correction is to take place by weight removal (−) or addition (+).

Line (5): T1 and T2 list the unbalance tolerance for each plane (3.70 g•in. each).

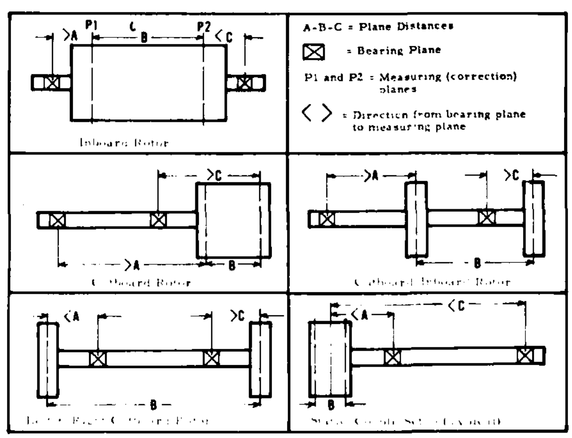

Figure 5. Rotor Configuration Examples

Line (6): Balancing speed is variable. It can be designated by the balancing specification. If not, the operator usually selects the lowest balancing speed at which the indicating sensitivity of the instrumentation is sufficient for the specified balance tolerance.

Line (7): F3 lists additional information for the component correction in the right plane (P2). Thus there are 12 equally spaced positions at which component correction can take place; the angular position of the first (or starting) component is at 8°.

Line (8): Field 4 permits identification of the rotor serial number (here 31).

Line (9): Field 5 Unbalance: This is the heading for lines (9) - (12).

Line (9) also shows the actual balancing speed.

Line (10)/
Line (11): The left column indicates the amount of unbalance (U1 = 28.0 g) in the left correction plane and its angular location (120°). The right column lists the two component positions (Nos. 8 and 9) in the right plane with their respective unbalance values (4.40 g and 19.6 g).

Line (12): States that the unbalance in both correction planes is out of tolerance.

The required unbalance correction is applied to the rotor; a second run is usually made to ascertain that the specified tolerance has been reached in both planes.

If more than one rotor of the same type is balanced, the rotor data in Field 2 are recalled and therefore need not be entered again. Only the new rotor serial number (F4) need be entered. Unbalance data for that rotor is then immediately displayed in Field 5 on the first run. If rotors of a different type are to be balanced, the rotor data of the first type can be stored in a memory file for later recall in case that type of rotor must be balanced again.

After the first run the rotor data and initial unbalance can be recorded in the form of the printed record shown in Figure 6. The record identifies the operator (F1); lists the rotor data (F2), (F3), (F4), and the initial unbalance (F5); and indicates whether or not the rotor is in tolerance. Thereafter, each run -- i.e., the new residual unbalance resulting from the previous unbalance correction -- can be added to the printed record.

```
F1  OPERATOR NUMBER  :5
F2  ROTOR DATA                DN= 14
    A= >2.80IN  B=  10.5IN  C= <3.15IN
    R1= 2.85IN  M1=-P R2= 3.75IN  M2=+K
    T1= 3.70GIN             T2= 3.70GIN
    BAL'G SPEED        N=     630.  RPM
F3                      P2=12START @  8.
F4  ROTOR SER.NO  RN=31
    RUN   1
F5  UNBALANCE:         N=     627.  RPM
    U1= 28.0G          POS  8     4.40G
    DEG=120.           POS  9     19.6G
    OUT OF TOL         OUT OF TOL


    RUN   2
F5  UNBALANCE:         N=     627.  RPM
    U1= 2.75G          POS 12    462.MG
    DEG= 57.           POS  1    28.0MG
    OUT OF TOL         IN TOL


    RUN   3
F5  UNBALANCE:         N=     627.  RPM
    U1= 625.MG         POS 12    303.MG
    DEG= 96.           POS  1    199.MG
    IN TOL             IN TOL
```

Figure 6. Typical Printout of Complete Balancing Cycle

The final printout registers the history of the unbalance measurements and corrections; the above example totaled three runs. Run 1 measured the initial unbalance; Run 2 measured the residual unbalance after correction was made in both planes. Note that the amount of unbalance now reads in milligrams in the right plane and is in tolerance. In the left plane a second correction was required because the initial unbalance was more than 10:1 larger than the specified tolerance. Run 3 measured the residual unbalance after the second correction was made in the left plane. (No further correction took place in the right plane.) The residual unbalance is now in tolerance in both planes, and the balancing operation is completed.

For mass production balancing a programmable micro processor instrumentation model CAB 600 is available. It permits subroutines directly applicable to different methods of unbalance correction. For

instance, the program can be made to interface with a drilling machine and control drill depth. The amount of unbalance, therefore, directly controls the material removal.

If the drive system of the balancing machine contains an indexing feature, the CAB 600 can be used to accomplish the proper indexing of the rotor so that the heavy spot, where material is to be removed, will be directly under the correction unit -- e.g., drill, milling machine, welder. Such features make the micro processor a highly flexible tool that will have a significant impact on developments in the balancing field.

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about optimization of structures under shock and vibration environment, and recent investigations of the propagation of finite amplitude multi-dimensional acoustic waves.

Dr. S.S. Rao of San Diego State University, San Diego, California has written an article defining a general structural optimization problem. A classification of structural optimization applications is based on the nature of the major behavior constraint. Recent work in each class of problems is reviewed. Developments in the area of optimization methods and sensitivity analysis are discussed.

Professor J.H. Ginsberg of Georgia Institute of Technology, Atlanta, Georgia has written a paper describing phenomena that arise in multi-dimensional systems in which wave intensity is not uniform transverse to the direction of propagation. Use of the direct method and applications of integral transforms in the analysis of wave propagation are described.

OPTIMIZATION OF STRUCTURES UNDER SHOCK AND VIBRATION ENVIRONMENT

S.S. Rao*

Abstract. *A general structural optimization problem is defined. A classification of structural optimization applications is based on the nature of the major behavior constraint. Recent work in each class of problems is reviewed. Developments in the area of optimization methods and sensitivity analysis are discussed. Structural optimization problems that need further investigation are summarized.*

A general structural optimization problem involves the determination of a set of design variables x_i, $i = 1, 2, \ldots, n$ that minimize the objective functions $f_1(\vec{X})$, $f_2(\vec{X})$, $\ldots$, $f_k(\vec{X})$ and satisfy the constraints $g_j(\vec{X}) \leq 0$, $j = 1, 2, \ldots, p$ and $l_j(\vec{X}) = 0$, $j = 1, 2, \ldots, q$. $\vec{X}$ is the design variable vector with $\vec{X}^T = \{ x_1, x_2, \ldots, x_n \}$, $g_j(\vec{X})$ is the j^{th} inequality constraint, and $l_j(\vec{X})$ is the j^{th} equality constraint. Most structural optimization investigations consider only one objective function with no equality constraints. In some cases the design variables x_i are considered functions of such parameters as spatial coordinates; the problem then becomes a trajectory optimization problem [56].

This paper presents a review of recent work in the field of structural optimization with dynamic constraints. It is convenient to classify structural optimization problems according to the major behavior constraint as follows:

- problems with natural frequency constraints
- problems with dynamic response restrictions
- problems with flutter constraints
- problems with reliability constraints
- design of vibration isolators and absorbers

A summary of recent work in each class is given below.

DESIGN PROBLEMS WITH NATURAL FREQUENCY CONSTRAINTS

Control and resonance of natural frequencies are important considerations in the design ʼ ʼnamic systems. Structural optimization techı ʒs have been applied to reduce the external vibı ʼs of a gas turbine engine [1]. An exterior penalʼ ʼnction method, coupled with the Gauss methoc ɹncon-strained optimization, has been applie ı a minimum mass design of truss structure ɪe fre-quency of vibration has been considered [3, 4] in the unimodal and bimodal optimal design of extensible arches and columns. The minimum weight design of structural members having lower bounds on the eigenvalues has been considered [5].

Optimal control (maximization) of the fundamental frequency of a plate of fixed weight with upper and lower bounds on the thickness has been discussed [6]. The thickness distribution of an axisymmetric plate has been determined by minimizing its volume for a given value of the fundamental natural frequency [7]. A method for an optimal design of symmetric fiber-reinforced composite laminates subjected to constraints on natural frequencies has been presented [8].

The design optimization of axially loaded, simply supported, stiffened cylindrical and conical shells for minimum weight has been considered by Rao and Reddy [9, 10]. Shell wall thickness, thickness and depth of rings and stringers, and number/spacing of rings and stringers were determined when natural frequencies, buckling strength, and direct stress were constrained. The use of allowable stress algorithms for a simple structural optimization problem with a single frequency constraint and a constant mass matrix has been discussed [11]. An optimality criterion method has been presented for obtaining the

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optimum configuration of structural elements undergoing large amplitude oscillations and subjected to a frequency constraint [12].

DESIGN PROBLEMS WITH DYNAMIC RESPONSE RESTRICTIONS

Limiting the dynamic response becomes important when a structure is subjected to wind loads, earthquakes, impacts, gusts, or blast waves. Minimization of the maximum deflection of beams subjected to harmonic excitation has been considered [13]. A formulation of an earthquake-resistant design for structural systems has been presented [14]. On the basis of current design philosophy two levels of performance constraints were imposed on the problem. The design problem was formulated as a min-max problem; then a general strategy was presented to transcribe the problem to the canonical form of a nonlinear programming problem. An interactive software system for the optimal design of civil engineering structures has been given [15]; the example used was the optimal design of a nonlinear single-degree-of-freedom impact absorber.

Optimum bearing-support damping for rotor/bearing systems from stability maps has been determined [16]. The dynamic response of a multimass, large-scale, flexible rotor mounted on antifriction bearings and a variable force friction damper has been investigated [19]. Experimental results indicated optimized damping for the system.

The optimal design of dynamically loaded rigid-plastic structures has been considered [18, 21]. A state space method for optimal design of structures under transient dynamic excitation was developed, and three problems were solved [17]. The optimization of damped dynamic structures has been considered [20]. An efficient technique has been presented by Masri and Safford [22] for optimizing the selection of pulse train characteristics to simulate the response of general types of structural systems to arbitrary dynamic environments. An adaptive random search algorithm was used that incorporated a periodic exploratory search for the optimal step-size variance. The same authors have presented an active control method for reducing the oscillations of distributed parameter systems subjected to arbitrary dynamic environments [23].

Mechanical dampers for the control of self-excited galloping of transmission lines have been considered by Rowbottom [24]. He recommends two dampers -- an in-span damper and a resilient mounting. Both dampers have been optimized either by maximizing the negative damping excitation that the damped system can withstand or by choosing the smaller logarithmic decrement of oscillation of the system to be as large as possible in the absence of excitation.

DESIGN PROBLEMS WITH FLUTTER CONSIDERATIONS

The control of flutter is important in such aircraft structures as wings, tails, and control surfaces, which are subjected to large lateral aerodynamic loads. The ideas presented by Haug and Arora [52] were used to determine the true optimal designs for structures undergoing flutter in the presence of damping [25]. A procedure for sizing an airframe for flutter-free performance has been demonstrated on a large flexible supersonic transport aircraft [26]. A two-level reduced basis or modal technique was used to reduce the computational cost of the repetitive flutter analysis.

A numerical procedure has been developed for minimizing the structural mass of an aircraft structure that must have a specified minimum flutter velocity or divergence velocity [27]. The arrangement of structural members was kept constant while the stiffness parameters were varied.

DESIGN OF VIBRATION ISOLATORS AND ABSORBERS

Vibration isolators and absorbers are devices that reduce or eliminate the unwanted effects of shock and vibration disturbances on critical elements of a mechanical system. A procedure to formulate redesign recommendations for suspending mass transport cars has been presented [28]. The objective of this study was to improve the performance of the suspension system under dynamic conditions so as to yield resonant velocities outside the range of most frequent operation. A state space method of optimal design of vibration isolators subjected to transient loads has been developed and applied [29]. Bullock and Cooley [30] described the design process followed in

developing a 100-ton freight car truck suspension system having Coulomb damping. The optimization of the actual design parameters and comparison to existing truck suspensions were accomplished using a late vehicle model.

A comparative study of various ride comfort criteria for the optimum design of a vehicle traveling on randomly profiled roads has been made by Dahlberg [31]. An optimization technique has been applied to evaluate the optimum values of the many parameters involved in the design of a pneumatic vibration isolation system; the maximum transmitted motion to the body would be minimum over a broad frequency range [32]. The optimal suspension structure for a simple one-degree-of-freedom vehicle model has been derived using linear-quadratic regulator theory [33].

An optimization system [34] to minimize the forced vibrational response of large-scale finite element models involves adjustment of isolator elements. This technique can be applied to models under steady state harmonic response and stationary random response.

Game theory has been used in optimization of shock and vibration isolation systems [35]. Results have been obtained for a three-degree-of-freedom system with an exponentially decaying base disturbance. A single-degree-of-freedom system was also used to evaluate the relative worth of a multi-degree-of-freedom system. Dual dynamic dampers have been proposed to replace viscous damping elements in isolators [36].

It has been shown that the equations of motion for a Lanchester damper can be modified to include the effects of both a damper slug rolling inside a cavity within the parent body and the kinetic energy of the damping fluid [37]. Slug rolling reduces the performance of the damper below that predicted by standard theory; a different value for damping is required at the optimum condition.

Warburton [47] determined the optimum parameters of absorbers. When they are attached to one mass of a main system with two degrees of freedom, the absorbers minimize the harmonic response of that mass. He also compared absorber parameters that were determined by either treating the main system as an equivalent one-degree-of-freedom system or using classical theory. He also showed how the optimum parameters of absorbers, which are attached to beams, plates, and cylindrical shells, can be obtained accurately from parameters of an equivalent single-degree-of-freedom main system [38, 48].

The problem of designing an optimum Lanchester damper for a viscously damped single-degree-of-freedom system subjected to inertial harmonic excitation has been investigated [39, 41]. The optimum design of an untuned viscous dynamic vibration absorber has been considered [40, 44]. The vertical and horizontal vibrations of a periodically forced vibration system with a magnetic absorber system (M.D.) have been analyzed [42]. The most favorable state in the principal mass was also discussed.

Computational graphs that can be used to determine the optimal linear vibration absorber for a linearly damped primary system have been presented [43]. A graphical procedure (frequency locus method) has been used [45, 46] to optimize an untuned viscous dynamic vibration absorber [40].

DESIGN PROBLEMS WITH RELIABILITY CONSTRAINTS

The weight optimization of indeterminate structures subjected to deterministic transient dynamic loads and reliability constraints has been determined [49]. Optimization algorithms, which incorporate analyses based on numerical integration of equations of motion and shock spectra, have been utilized. A mathematical programming method for formulating an optimum design problem for structural systems using random parameters has been presented by Rao [50]; the systems are subjected to random vibration. The method was applied to the optimum design of a cantilever beam with a tip mass and a truss structure supporting a water tank. The time parameter that appears in the random vibration-based constraints was eliminated by replacing the probabilities of failure by suitable upper bounds.

OPTIMIZATION METHODS

Various optimization methods, including nonlinear programming and optimal control techniques have

been compiled, as have their applications to structural and machine design problems [52, 54]. Various optimum design methods and their applications to engineering problems have been given [56]. Stochastic programming methods, which are useful for structural design problems involving random variables and random processes, are discussed in detail.

A survey of the applications and uses of optimization in aeronautical structural design has been presented [51]. Ideas and trends in optimization have been summarized [53]. An evaluation of the optimization software available in engineering design has been published [55], as has a discussion of the current state and future prospects of optimization in design [58]. The latter paper emphasizes the use of computerized algorithms and evolutionary and intuitive processes in optimal design.

A multilevel approach has been applied to the minimum weight structural design of wing box structures with fiber-composite stiffened-panel components [57]. The optimum sensitivity problem, which involves determination of derivatives of the optimal objective function and design variables with respect to physical quantities that are kept constant as problem parameters during optimization, has been considered [59]. The sensitivity equations derived in this work are applicable to optimum solutions obtained by direct search methods as well as those generated by SUMT methods. Recent developments in analytical, noniterative, and global optimization methodologies have been given by Wilde [60].

CONCLUSION

This review of recent work on structural optimization under shock and vibration environments indicates that the following problems need further investigation:

- the solution of design problems with discrete or integer design variables
- the application of multilevel and decomposition techniques for the solution of large-scale design problems with dynamic constraints
- reliability-based design problems involving stochastic processes with non-Gaussian inputs

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RECENT INVESTIGATIONS OF THE PROPAGATION OF FINITE AMPLITUDE MULTI-DIMENSIONAL ACOUSTIC WAVES

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Abstract. Phenomena are described that arise in multi-dimensional systems in which wave intensity is not uniform transverse to the direction of propagation. Use of the direct method and applications of integral transforms in the analysis of wave propagation are described.

Earlier review articles [1, 2] described a variety of interesting phenomena that arise when acoustical waves have reasonably large amplitudes; e.g., in excess of 120 dB (re 20 μPa) in air or 210 dB (re 1 μPa) in water. The phenomena of wave steepening and formation of shocks in planar waves are well-documented.

The effects that arise in multi-dimensional systems, in which wave intensity is not uniform transverse to the direction of propagation, are less familiar but equally dramatic. Various techniques have been employed to evaluate these effects. Multi-dimensional systems have resisted exact analytical solutions. As a result analytical solutions using perturbation methods have received a great deal of attention.

GENERAL CONCEPTS

Consider the case of linear waves when the signal strength is infinitesimal. In general, the acoustic medium is nondispersive; that is, a one-dimensional wave having infinitesimal amplitude will propagate at the speed of sound regardless of its wavelength. However, the speed at which nonuniform waves propagate is dependent on the rates of variation in the propagating and transverse directions, as might be measured by a ratio of wavelengths. In fact, waves having comparatively small transverse wavelengths decay exponentially rather than propagate [3]. Because the phase speed for propagating waves is dependent on a ratio of wavelengths in orthogonal directions, individual waves are often found to propagate jointly. Thus an acoustic wave can be considered to be comprised of groups of waves having different wave speeds.

Let p denote the acoustic pressure and v_1, v_2, v_3 the particle velocity components. Then

$$\begin{Bmatrix} p \\ v_1 \\ v_2 \\ v_3 \end{Bmatrix} = \sum_{i=1}^{M} \begin{Bmatrix} p \\ v_1 \\ v_2 \\ v_3 \end{Bmatrix}_i \qquad (1)$$

where i represents the group number. Each group has a unique phase speed, which is denoted as c_i.

Let x_1 be the direction of propagation. Then each group can be written as

$$\begin{Bmatrix} p \\ v_1 \\ v_2 \\ v_3 \end{Bmatrix}_i = \sum_{j=1}^{M} \begin{Bmatrix} (p)_{ij} \\ (v_1)_{ij} \\ (v_2)_{ij} \\ (v_3)_{ij} \end{Bmatrix} \qquad (2)$$

The terms to the right of the equality sign are functions of $t-x_1/c_i$, x_2, and x_3.

The lack of dispersion for the individual contributors to a specific group i has a profound nonlinear effect. For discussion purposes nonlinearity can be considered to create source terms that excite a second order linear signal. Because these source terms propagate at the speed of the group from which they are formed, a resonant-like condition is established. This leads to a cumulative growth of distortion effects as the group propagates.

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PERIODIC GEOMETRIES

The direct method described in preceding surveys [1, 2] has been particularly successful in evaluating nonlinear effects. The first step in the direct method is to formulate the problem in terms of the nonlinear hyperbolic wave equation governing the velocity potential [4]. This partial differential equation is solved asymptotically using a singular perturbation method [5]. Most investigators have used the method of renormalization, in which coordinate straining transformations are introduced to describe the distortion associated with nonlinearity.

The systems treated in this section have repetitive geometric configurations. This permits the use of separation of variables to solve the linear differential equations.

The study of two-dimensional waves in a hard-walled duct [6] was significant in the development of the direct method because of the general nature of the excitation. An arbitrary periodic input excited a variety of duct modes that were grouped according to phase speeds. It was found that the distortion of each mode forming a nondispersive group is a consequence of all modes in that group. Furthermore, the distortion is not influenced by the responses in other groups. This conclusion resulted from the fact that a different coordinate straining was found for each group. Because the system was two dimensional, two strained coordinates were introduced. For group i, they had the form

$$\begin{aligned} t - x_1/c_j &= \alpha_i + F_i x_1 (v_1)_i \\ x_2 &= \beta_i + G_i x_1 (v_2)_i \end{aligned} \qquad (3)$$

where F_i and G_i are constants. Each term $(p)_{ij}$, $(v_1)_{ij}$, and $(v_2)_{ij}$ ($j = 1, 2, \ldots, N$) depends on the values of α_i and β_i. A constant value of α_i defines a wave front for group i, and constant β_i is a ray. Thus, equations (3) define a phenomenon of self-refraction, in which the wave fronts and rays for a group are distorted by the response in the group.

A similar conclusion was obtained in an analysis of the acoustical waves that result when oppositely traveling waves propagate along an infinite plate [7]. That investigation followed the method of renormalization for an inviscid medium. However, the method of multiple scales, with its increased generality and complexity was required to develop the coordinate straining in the presence of dissipation.

The tendency for non-dispersive groups to interact only with themselves has been identified in general cylindrical [8, 9] and spherical [10, 11] waves. These analyses developed the solutions in terms of eigenmodes of the respective curvilinear coordinate system. The analytical techniques employed followed the grouping concepts developed for the duct problem. The method for evaluating the second order potential function in curvilinear coordinates was identical to that derived for excitation in a single cylinder harmonic [12, 13]. In that procedure the asymptotic expansion of the response in the far field is used to ascertain the coordinate straining. The result is then matched to the expansion of the response in the near field.

The primary differences in the analyses of cylindrical and spherical waves arise from differences in the nature of the dispersion. In the far field, infinitesimal spherical waves propagate at the speed of sound, regardless of the spherical harmonic to which they correspond. Thus, only a single wave group existed in the spherical geometry.

APPLICATIONS FEATURING INTEGRAL TRANSFORMS

A key element in the foregoing analyses was the identification of the portion of the second order potential that grows as the wave propagates. Identification was expedited by the fact that the analogous linearized system could be analyzed by separating variables in the governing partial differential equation. Many systems encountered in practice require more general solution techniques. The feasibility of using integral transforms in the context of the direct method was demonstrated in a study of planar waves [14]. The Laplace transform was used in the analysis to treat an arbitrary time dependence. The coordinate straining, which was performed in terms of the transform, was shown to reduce to the result obtained by more conventional methods.

Integral transforms have been implemented in the analysis of systems related to the infinite baffle problem. Such systems feature the oscillation of a

flat boundary, which results in a confined beam of sound when the frequency is sufficiently high. The linear solution of these problems is usually formulated in terms of source theory, which leads to the Rayleigh integral [3]. However, an alternative formulation using integral transforms has proven to be more convenient for nonlinear problems.

The case of an infinitely long strip on the boundary was treated first. A Fourier cosine transform was used in an evaluation of the growth of harmonics [15] to treat the variation transverse to the axis of propagation. The propagating part of the first order signal was

$$\phi_1 = \int_0^1 \frac{V_k}{\lambda_k} \cos(t-\lambda_k x_1)\cos(kx_2)dk \qquad (4)$$

where $\lambda_k = (1 - k^2)^{1/2}$ and V_k is a transform parameter for the excitation. A comparison of this representation with equations (1) and (2) reveals that the sound beam is composed of a continuous spectrum of infinitesimal wave groups. Each group consists of a single harmonic that propagates at the nondimensional speed $1/\lambda_k$.

Equation (4) leads to source terms occupying a double spectrum of transverse wave numbers k. An analysis [15] reduced the double spectrum to a single one by means of an asymptotic integration (the method of stationary phase). In essence this procedure describes the cancellations resulting from destructive interference between higher harmonics. The part found in the integration represents the primary contribution to the far field.

The potential function that resulted from this analysis was the starting point for a companion study [16] to determine coordinate straining. It was found that the transformation is dependent on the transverse wave number, specifically

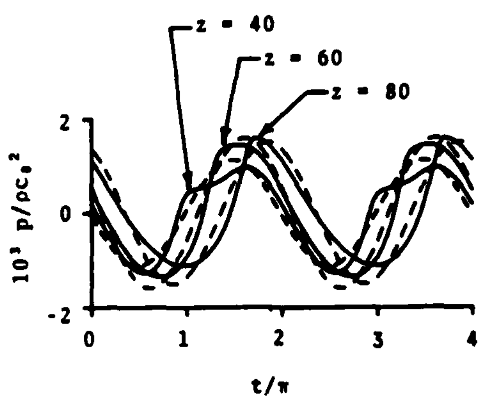
$$\begin{aligned} t-\lambda_k x_1 &= \psi_k - \epsilon s_k x_1^{1/2} \sin(\psi_k - \pi/4)\cos(\eta_k) \\ kx_2 &= \eta_k - \epsilon s_k x_1^{1/2} \cos(\psi_k - \pi/4)\sin(\eta_k) \end{aligned} \qquad (5)$$

where ψ_k and η_k are the strained coordinates, and s_k is a coefficient that depends on V_k and λ_k. The variables ψ_k and η_k replace $t-\lambda_k x_1$ and kx_2 respectively in equation (4).

This result is consistent with the earlier observation regarding wave groups. Each infinitesimal segment in the spectrum of transverse wavelets forms a wavelet. Because the phase speed of the wavelet is an analytical function of its wave number, it forms an individually propagating group. The distortion of each group is independent of the response in other groups.

The same type of analysis was employed to study the more realistic problem of axisymmetric sound beams [17]. The unique feature was the treatment of the variation of the signal transverse to the beam axis. Because it was convenient to use cylindrical coordinates to treat the spatial dependence, a Hankel (Fourier-Hankel) transform was used. The analysis of the second order potential was achieved off the beam axis in order to simplify the representation of the Bessel functions that appear in the integral transform. The method whereby the off-axis response was matched to the on-axis result is derived from the treatment of cylindrical waves that propagate in the radial direction [12].

The waveform in both the strip and axisymmetric beam configurations displayed a type of distortion that is not observed in periodic geometries. Wave steepening due to amplitude dispersion occurs even in one-dimensional waves [3]. The figure displays some typical waveforms for the axisymmetric sound beam; it exhibits such distortion. (The dotted curves are the predictions of linear theory.) It can be seen that the shape of the compression phase is high and narrow; the rarefaction phase is broad. This prediction is consistent with experimental observations [18, 19].



Waveforms on Axis in an Intense Sound Beam in Water. ka = 20; maximum pressure, 240 dB

Comparable predictions have been reported in the Soviet literature [20-25]. In these analyses finite difference techniques were used to solve a modified version of Burger [26] that is often used as a prototypical equation for nonlinear waves. The modification [27, 28] is intended to account for spreading transverse to the beam axis. However, the assumptions made in the derivation of the modified equation are prone to error when small scale diffraction effects are involved.

Analyses and experimental observations of sound beams indicate that the asymmetry in the profile occurs when the excitation is sufficiently strong to cause significant distortion in the near field, where the beam resembles a quasi-planar wave [19]. Less strong excitations result in a transition of the sound beam to a quasi-spherical in the far field [3]. The mechanism underlying this change in distortion type is a current research topic.

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BOOK REVIEWS

SNUBBER DESIGN APPLICATIONS AND MINIMIZATION METHODS

F.M. Fredrickson, Editor
ASME Publ. PVP Vol. 55, New York, NY
1981, 75 pages, $14.00

A snubber is a dynamic or shock restraint device; it is used in large numbers to support piping systems and equipment in the nuclear power industry. A snubber allows essentially free motion to low rates of relative displacement between its two ends. It resists shock or vibration sensed by either relative acceleration or relative velocity between its two ends.

The book is comprised of seven independent papers covering various topics on snubbers. All were written by practicing engineers in the industry. The book is easily understood; essentially no mathematics are involved.

E.J. Renkey reports that tests on low level vibration indicate an increase in the breakaway force due to contamination by wear particles. He states that inspections performed on seismic restraints installed in high vibration areas have verified wearing in those snubbers.

F.E. DiCola presents a program for establishing examination and testing criteria for verifying snubber operability. He identifies both the sources of data to be used for establishing such criteria and the contents of the criteria. The author recommends that criterion values specific to location rather than generic criteria be used. No actual criterion data are presented in the paper.

L.S. Rapel discusses the need for consideration of lateral loading of snubber assemblies. He provides methods for qualifying the assemblies for lateral load. The author points out that lateral loads result in shortening the allowable pin-to-pin dimension of a snubber assembly and that a stiffer extension member may be required.

In 25 pages G.T. Jirak and C.L. Braff describe a wide range of problems related to snubbers encountered at Diablo Canyon Nuclear Power Plant; the resolutions of the problems are also given. Those who want to improve their snubber inspection or surveillance check lists will find this article worth reading.

R.T. Anderson and W.W. Van Meter describe the functions, mechanisms, and characteristics of various types of snubbers currently used in the industry. They present a concept for an electro-mechanically controlled snubber. The authors also describe the advantages and benefits that might be realized by use of an electro-mechanical snubber. The disadvantages -- including the requirement for a redundant power supply for safety-related systems and possible disastrous consequences to control room operators – are not mentioned.

H.J. Thailer presents the necessary considerations associated with the design of a rigid pipe clamp assembly more engineered than the band clamps traditionally used. The paper is different from typical design textbooks or journals in that neither a design analysis procedure nor a computer code used for optimum design is given. The reader will find the content of the article strictly limited to considerations.

D.J. Graziano and R.M. ElBeshbeshy present methods for reducing the number of snubbers in designing piping systems. The methods include accounting for support stiffness, accounting for gaps between support and pipe, strategic placement of support, and full use of material strength allowed by codes.

The book should benefit those who participate in design, analysis, installation, and inspection of pipe and pipe supports involving snubber applications, including snubber vendors.

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FLUID TRANSIENTS AND STRUCTURAL INTERACTIONS IN PIPING SYSTEMS

P.H. Rothe and D.C. Wiggert, Editors
ASME Publ., New York, NY
Book No. G00198, 1981, 53 pages, $14.00

Vibrations of piping due to fluid transients and fluid-pipe interactions are two significant causes of pipe failures; they affect safety, reliability, and availability of nuclear power and certain other process plants. The six papers illustrate recent progress related to the description and analysis of fluid transients and how they interact with piping.

The first paper describes a numerical analysis approach that simulates the effects of fluid-acoustic and fluid-piping interaction. The analysis utilizes a piping structure finite element analysis code; the fluid in the pipe is represented by spar elements.

The second paper presents a numerical analysis approach using existing dynamic structural analysis computer codes. The method for studying dynamic fluid-piping interaction by separate analyses of fluid and solid components is followed by modal synthesis of the component solutions.

The third paper deals with two methods for calculating overall transfer matrix and pressure pulsation amplitude at certain locations within a special parallel bridge type network. The technique was applied to simulate and analyze the acoustic performance of a piping system. It was also used to attenuate pressure pulsation through acoustic performance of a piping system and to attenuate pressure pulsation through acoustic tuning.

The fourth paper utilizes a two phase thermal hydraulic code, RELAP4, and a water hammer code to analyze a blowdown terminated by check valve closure. The authors point out that piping components, their relative locations, and the values of their characteristics dictate the phenomena and the analysis method involving two-phase fluid transients.

The authors of the fifth paper report their experience in using RELAP4/MOD5 and REPIPE for calculating piping loads on a feedwater line due to check valve closure. Conclusions on nodalization, time-step, frequency of printout, and spurious oscillation of solutions are applicable to more recent similar codes such as RELAP5/MOD1 - REFORC developed for safety and relief valve evaluation.

In the sixth paper the authors report that a laboratory scale apparatus had provided repeatable data on waterhammer transients of bubble collapse. They state that experimental results are consistent with simple, one-dimensional theoretical analysis of both bubble collapse dynamics and piping structural responses.

The book contains results of good research work and some original data. Theoretical treatment, illustrative examples, and suggestions on optimum system design parameters are well balanced. Fifty references are listed in the second and the third papers alone. The book should benefit university researchers and engineering specialists interested in keeping abreast of the state of the art in the subject field.

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BEARING DESIGN -- HISTORICAL ASPECTS, PRESENT TECHNOLOGY AND FUTURE PROBLEMS

W.J. Anderson, Editor
ASME Publ., New York, NY
Book No. H00160, 1980, 212 pages, $30.00

This book, edited by W.J. Anderson, is a collection of six papers originally presented at the ASME Century 2 - Emerging Technology Conferences held at San Francisco, August 18-21, 1980. The papers outline the achievements of the last decade and provide direction for future developments in bearing materials, bearing design, operating performance prediction capability, extension of bearing life, and reliability. Emphasis is on dynamically loaded bearings.

The first three papers discuss aspects of materials, analysis, and lubrication of rolling element bearings.

In a paper on materials for rolling element bearings E.N. Bamberger reviews the development of bearing materials from the invention of the rolling contact bearing to the present. He illustrates advances with examples from his industrial experience in the aircraft industry. The various material aspects discussed include fracture toughness, surface hardened materials, through hardened materials, hollow rolling elements, ceramics, and metallurgical and chemical effects. The author admits that his review is from a narrow viewpoint in that the work mainly relates to high performance aircraft engine bearings; but many applications in general industry could operate under similar conditions.

The second paper is on computerized analysis and design methodology for rolling element bearing load support systems. J. Pirvis describes advances in the computer analysis of rolling element bearings and presents a survey of the software used by various workers. He advocates system design as opposed to component design and describes the use of computer software packages for selecting rolling element bearings. Three appendices provide details of software suitable for prototype design of a system, typical input/output computer information, and shaft bearing analysis. A minor discrepancy is that the first word in the title of the paper is different from the title in the contents page.

In the third paper R.J. Parker provides a broad survey of the lubrication of rolling element bearings. He covers the basic function of a liquid lubricant and describes the state of technology and limitations of the following methods of lubrication: solid film, grease, jet, splash and bath, wick lubrication, and air/oil mist. Parker outlines the gains that have been made in the last decade to extend the speed capability of rolling element bearings. He also explains how the useful temperature range can be extended with the use of under-race and outer-race cooling. Lubrication-related surface failure modes are illustrated with good photographs.

The fourth paper on journal bearing design for high speed turbomachinery by P.E. Allaire and R.D. Flack outlines the problems that can arise in plain journal bearings operating at very high speeds. Considerable discussion is devoted to the type of bearing that can be used to reduce or eliminate vibrations; the types include multi-lobe bearings, tilting pad bearings, hydrostatic bearings, offset bearings, partial bearings, and elliptical bearings. Theoretical and experimental data for some of these bearings are presented to demonstrate vibration reducing characteristics at high speed. A useful summary chart outlines the advantages and disadvantages of various types of bearing geometries. Detailed descriptions of experimental rotor test rigs and related instrumentation are given in the appendices.

The fifth paper on turbulent flow bearing design and energy losses by C.M. Taylor contains a considerable literature survey on the subject. He reviews theoretical and experimental work relating to energy losses due to non-laminar flow. Experimental data on bearing temperatures and the transition from laminar to superlaminar flow conditions in journal bearings are discussed. The author provides a critique of four design procedures on the analysis of bearings operating in turbulent regimes and guidance on selecting the geometry of bearings to minimize power loss during operation in the turbulent flow conditions. An appendix contains a brief background to currently available lubrication theories and a summary of the development of philosophies and their limitations.

The final paper on fluid-film bearing response to dynamic loading was written by W. Shapiro. He uses examples to illustrate the time transient method, which traces the history of the motion of a bearing system under subjected loading. He also describes the analysis of incompressible and compressible fluid-film bearings operating under dynamic loading conditions by such techniques as numerical solutions of lubrication equations, field mapping of bearing characteristics, and short bearing approximations.

The book contains a useful literature survey and many references and therefore should be ideal for postgraduate students who are beginning research into bearing design.

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BOOK REVIEWS: 1982

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SHORT COURSES

JANUARY

RELIABILITY METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 10-14, 1983
Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Building No. 76, Room 237, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3054.

FEBRUARY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: February 7-11, 1983
Place: Santa Barbara, California
Dates: March 7-11, 1983
Place: Washington, DC

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (805) 682-7171.

PERIPHERAL ARRAY PROCESSORS FOR SIGNAL PROCESSING AND SIMULATION

Dates: February 15-18, 1983
Place: Los Angeles, California

Objective: The primary emphasis of this course is on the application of peripheral array processors to the principal problems arising in the processing of sampled analog signals. These include particularly the problems of spectral analysis (Fast Fourier Transform), filtering, and autocorrelation, which are typical of signal processing applications.

Contact: Short Course Program Office, UCLA Extension, P.O. Box 24901, Los Angeles, CA 90024 - (213) 825-1295 or 825-3344.

MACHINERY VIBRATION ANALYSIS

Dates: February 22-25, 1983
Place: Tampa, Florida
Dates: June 14-17, 1983
Place: Nashville, Tennessee
Dates: August 16-19, 1983
Place: New Orleans, Louisiana
Dates: November 15-18, 1983
Place: Chicago, Illinois

Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SYSTEMATIC APPROACH TO IMPROVING MACHINERY RELIABILITY IN PROCESS PLANTS

Dates February 23-25, 1983

Place San Francisco, California

Objective This seminar is intended to guide machinery engineers, plant designers, maintenance administrators, and operating management toward results-oriented specifications, selection, design review, installation, commissioning, and post start-up management of major machinery systems for continued reliable operations. Emphasis will be on pumps, compressors, and drivers.

Contact: Sherry Theriot, Professional Seminars International, P.O. Box 156, Orange, TX 77630 - (713) 746-3506.

MARCH

EXPLOSION HAZARDS EVALUATION

Dates: March 14-18, 1983

Place: San Antonio, Texas

Objective: Fundamentals of combustion and transition to explosion including recent experimentation on large-scale systems, current testing techniques and their utility, accidental explosions, and preventive measures are reviewed. Free-field explosions and their characteristics including definition of an explosion, characteristics of explosions, and the fallacy of "TNT" equivalence are defined. Loading from blast waves such as reflected waves -- both normal and oblique, diffraction and diffracted loads, internal blast loading, and effects of venting will be covered. Structural response to blast and non-penetrating impact including approximate methods, the P-i concept, Bigg's methods, numerical methods, and applicable computer codes will be reviewed. Fragmentation and missile effects (trajectories and impact conditions), thermal effects (fireballs from explosions and radiation propagation), damage criteria (buildings, vehicles, and people), and design for blast and impact resistance (general guidelines, design using approximate methods, and computer-aided design) will be reviewed.

Contact: Ms. Deborah Stowitts, Southwest Research Institute, P.O. Drawer 28510, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

INTERNATIONAL CONFERENCE ON CONSTITUTIVE LAWS FOR ENGINEERING MATERIALS – THEORY AND APPLICATION

January 10-14, 1983

Tucson, Arizona

An International Conference on Constitutitve Laws for Engineering Materials -- Theory and Application will be held January 10-14, 1983 at the Ramada Inn, 404 North Freeway, Tucson, Arizona. This conference is sponsored by University of Arizona, College of Engineering, Tucson, Arizona with financial support from the National Science Foundation, Washington, DC.

The importance of constitutive laws of engineering materials for reliable solutions from analytical and computational procedures has been recognized by the researcher and practitioner. This growing recognition has resulted in significant recent activity towards theoretical and experimental research, and implementation of the laws in various solution procedures.

The major objective of the conference is to provide a bridge between theoretical developments and implementation in order to enhance the potential for applications of various constitutive laws to the solution of engineering problems.

About 100 papers will be presented in the areas of: general theory; metals and composites; geological materials; discontinuous media, interfaces, joints; concrete; granular materials and aggregates; and implementation and evaluation. Papers on elasticity/hypoelasticity, plasticity, viscoelasticity/plasticity, rate type, endochronic and micromechanics/damage models are included under the seven topics. Participants include some of the outstanding persons active in theoretical developments and applications of constitutive laws of a wide range of engineering materials.

For further information contact: Office of Special Professional Education, College of Engineering, Harvill Building, University of Arizona, Tucson, Arizona 85721 - (602) 626-3054.

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
Springs
Tires and Wheels
Blades
Bearings
Belts
Gears
Clutches
Couplings
Fasteners
Linkages
Valves
Seals
Cams

STRUCTURAL COMPONENTS

Strings and Ropes
Cables
Bars and Rods
Beams
Cylinders
Columns
Frames and Arches
Membranes, Films, and Webs
Panels
Plates
Shells
Rings
Pipes and Tubes
Ducts
Building Components

ELECTRIC COMPONENTS

Controls (Switches, Circuit Breakers)
Motors
Generators
Transformers
Relays
Electronic Components

DYNAMIC ENVIRONMENT

Acoustic Excitation
Shock Excitation
Vibration Excitation
Thermal Excitation

MECHANICAL PROPERTIES

Damping
Fatigue
Elasticity and Plasticity

EXPERIMENTATION

Measurement and Analysis
Dynamic Tests
Scaling and Modeling
Diagnostics
Balancing
Monitoring

ANALYSIS AND DESIGN

Analogs and Analog Computation
Analytical Methods
Modeling Techniques
Nonlinear Analysis
Numerical Methods
Statistical Methods
Parameter Identification
Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

Conference Proceedings
Tutorials and Reviews
Criteria, Standards, and Specifications
Bibliographies
Useful Applications

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (DA), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, DC 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2497, 2556)

82-2490

A Remark on the Stability of Linear-Viscoelastic Rotating Shafts (Eine Anmerkung zur Stabilität linear-viskoelastischer rotierender Wellen)

D. Ottl

Lehrstuhl A f. Mechanik der TU Braunschweig, Postfach 3329, D-3300 Braunschweig, Bundesrepublik Deutschland, Ing. Arch., 52 (3/4), pp 275-285 (1982) 7 figs, 10 refs

(In German)

Key Words: Shafts, Rotors, Viscoelastic properties, Stability

The stability of rotating shafts is investigated by means of a perturbation technique and the results assuming a Voigt-Kelvin-material and a linear-viscoelastic material are compared.

82-2491

Finite-Element Analysis for Rotating Equipment

S. Lin

Reliance Electric Co., Greenville, SC, Mach. Des., 54 (15), pp 63-65 (June 24, 1982)

Key Words: Rotors, Centrifugal forces, Computer programs

A procedure which modifies general purpose computer programs to account for centrifugal forces in high speed rotating machinery is presented.

82-2492

A Velocity Parameter for the Correlation of Axial Fan Noise

T. Wright

Fluid Systems Lab., Westinghouse Electric Corp., 1291 Cumberland Ave., West Lafayette, IN 47906, Noise Control Engrg., 19 (1), pp 17-25 (July-Aug 1982) 9 figs, 2 tables, 19 refs

Key Words: Fan noise, Blades, Noise prediction

An aerodynamic parameter is proposed to relate subsonic axial fan noise to the fundamental flow behavior in the blade row of the fan. This parameter is the peak or maximum blade surface velocity in the rotating reference frame and includes, either explicitly or implicitly, the influence of tip speed, volume flow rate, pressure rise, shaft horsepower and efficiency. Correlation of the noise associated with a very broad range of axial fans – ranging from very lightly loaded household fans to high-speed, high-pressure industrial fans and aircraft propulsion fans – yields good agreement and collapse of data when compared to currently-used correlation methods. Use of this parameter, rather than those based on overall performance, allows trade-off studies to be made within a given performance requirement so that a minimum noise configuration may be designed or selected.

82-2493

An Iterative Finite Element - Integral Technique for Predicting Sound Propagation from Turbofan Inlets

S.J. Horowitz

Ph.D. Thesis, Georgia Inst. of Tech., 305 pp (1982) DA8215262

Key Words: Turbofans, Sound propagation, Wave propagation, Finite element technique, Iteration

A new approach to solving the problem of predicting the sound field radiated from a turbofan inlet in flight has been developed. The sound field is divided into two regions: the sound field within the inlet (internal problem) which is modeled using finite elements and the radiation field outside the inlet (external problem) which is modeled using an integral technique. A complete solution is obtained by assuming the distribution of the radiation impedance along the interface between the internal and external regions and then iterating the finite element and integral solutions until convergence is obtained.

METAL WORKING AND FORMING

82-2494

Workpiece Response in Turning due to Spatially Moving Random Metal Cutting Forces

R.B. Bhat, A.M. Sharan, and T.S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, Mech. Mach. Theory, 17 (4), pp 249-254 (1982) 3 figs, 9 refs

Key Words: Machine tools, Interaction: machine tool-workpiece, Cutting

The nonstationary random response of a workpiece subjected to a constantly varying cutting tool contact in a metal turning operation is investigated. The ensemble of the applied forces is modeled as a white noise process. The workpiece is considered to be a uniform beam with fixed-hinged boundaries and with viscous damping. The results indicate that the workpiece response at the cutting tool contact is not significantly influenced by the tool feed rate for normal metal turning operations.

82-2495

Machine Tool Chatter

M.K. Das

Mech. Engrg. Dept., Univ. of Birmingham, UK, Chartered Mech. Engrg., 28 (8), pp 22-27 (Sept 1981) 11 figs, 1 table, 22 refs

Key Words: Machine tools, Chatter, Self-excited vibrations

The metal removal capacity of machine tools is often limited by self-induced vibration or chatter. This article discusses the reasons for it and how it can be reduced.

82-2496

A Theoretical Method of Minimizing Vibration and Noise Generation of a High Energy Rate Forming Machine Structure

H.F. Vasconcelos and S. Taylor

Dept. of Mech. Engrg., Paraiba Univ., Brazil, IMechE, Proc., Vol. 196, pp 183-190 (June 1982) 4 figs, 8 tables, 12 refs

Key Words: Noise reduction, Vibration control, Machine tools, Finite element technique, Optimization

A technique for the numerical optimization of a finite element model of a high energy rate forming machine is introduced. Both the nature of the impulsive loading and selected structural dimensions are optimized with respect to a simple measure of the noise created during a forging operation. The authors conclude that the technique could be applied to other structures or could be based on a more sophisticated noise criterion although dynamic finite element analyses demand considerable computing power.

82-2497

Mechanics of Cutting and Boring. Part 7. Dynamics and Energetics of Axial Rotation Machines

M. Mellor

Cold Regions Res. and Engrg. Lab., Hanover, NH, Rept. No. CRREL-81-26, 47 pp (Dec 1981)
AD-A113 931

Key Words: Drills, Machine tools

This report deals with force, energy and power in machines such as drills and boring devices, where the cutting head rotates about a central axis while penetrating parallel to that axis. Starting from a consideration of the forces developed on individual cutting tools, or segments of cutters, the thrust and torque on a complete cutting head is assessed, and simple relationships between thrust and torque are derived. Similarly, the energy and power needed to drive the cutting head are estimated and related to tool characteristics. Design characteristics of existing machines are compiled and analyzed to give indications of thrust, torque, power, effective tool forces, nominal thrust pressure, power density, and specific energy.

STRUCTURAL SYSTEMS

BRIDGES

82-2498

Prediction and Control of Pedestrian-Induced Vibration in Footbridges

J.E. Wheeler

Bridge Des. Main Roads Dept., Waterloo Crescent, East Perth, Western Australia 6000, ASCE J. Struc. Div., 108 (9), pp 2045-2065 (Sept 1982) 15 figs, 1 table, 19 refs

Key Words: Bridges, Traffic-induced vibrations, Vibration prediction, Vibration control

Footbridges vibrate because the forces imparted by the user are applied with the frequency of the pace; and movement,

however small, is therefore a forced vibration. In instances where the pace coincides with a structure resonant frequency dynamic movement can be quite large and the user may be disturbed or even alarmed. Vibration is recognized as a serviceability limit state and a process that can be employed as a design tool permitting an early assessment of behavior is proposed. The subject is investigated in terms of the pedestrian excitation source, the structure response, and acceptance criteria. Calculated response compares favorably with test results. Remedial or preventative options in the form of various damping devices are reviewed.

82-2499

Lateral-Distribution Factors for Fatigue Design

C.G. Schilling
Res. Lab., U.S. Steel Corp., Monroeville, PA 15146,
ASCE J. Struc. Div., 108 (9), pp 2015-2033 (Sept 1982) 8 figs, 3 tables, 21 refs

Key Words: Bridges, Beams, Steel, Fatigue life, Finite element technique

An extensive finite-element parametric study developed a chart giving lateral-distribution factors for the fatigue design of steel highway bridges. The chart gives conservative upper-limit factors for interior and exterior beams. The factor for interior beams is 0.5. The factor for exterior beams varies with the distance from the beam to the outer traffic lane and reaches a value of 0.9 when the center of the lane is directly over the beam. These upper-limit values can be used to make an initial fatigue check.

82-2500

Impact Factors for Fatigue Des· n

C.G. Schilling
Res. Lab., U.S. Steel Corp., Monroeville, PA 15146,
ASCE J. Struc. Div., 108 (9), pp 2034-2044 (Sept 1982) 4 figs, 2 tables, 27 refs

Key Words: Bridges, Steel, Fatigue life, Impact shock, Traffic-induced vibrations

Theoretical and experimental information is presented on impact factors for the fatigue design of steel highway bridges. Theoretical studies suggest that the impact factors for individual trucks in actual traffic should generally be less than 0.25, but that much higher factors would occur occasionally due to unusual conditions, such as a bump at a critical location. Measurement of impact factors in actual steel bridges confirms these theoretical conclusions.

82-2501

Spectra of Road Surface Roughness on Bridges

H. Honda, Y. Kajikawa, and T. Kobori
Dept. of Civil Engrg., Kanazawa Inst. of Tech., 7-1 Ogigaoka, Nonoichi-Machi, Ishikawa 920, Japan,
ASCE J. Struc. Div., 108 (9), pp 1956-1966 (Sept 1982) 11 figs, 1 table, 16 refs

Key Words: Bridges, Surface roughness, Power spectral density, Moving loads

The power spectral density (PSD) of road surface roughness on highway bridges is presented. Eighty-four lines on 56 bridges were measured and the road surface roughness was measured by surveyor's level. The PSD is assumed by a stationary normal probability process with a zero mean value, and is calculated by a maximum entropy method (MEM) to a measured value of road surface roughness. Numerical examples are presented to obtain the information of road surface roughness on bridges in spectral characteristics, and to give the appropriate PSD using the dynamic response analysis of bridges under moving vehicles.

BUILDINGS

82-2502

Airborne Sound Insulation and Graphical Indices

J. Parmanen and H.T. Tuominen
Technical Res. Ctr. of Finland, SF-02150 Espoo 15, Finland,
J. Sound Vib., 82 (2), pp 235-245 (May 22, 1982) 2 figs, 5 refs

Key Words: Buildings, Structural members, Acoustic insulation

The use of graphical indices is interpreted as an approximate approach to the estimation of sound insulation performance of building elements. Differences of weighted sound pressure levels are considered as quantitative measures for subjective sound insulation. The indices considered are formed by shifting a reference curve until the highest position is found at which certain specifications, or rules, are met. General expressions are mathematically derived for the maximum differences between gra· ·l indices and sound insulation in two cases: a maximun ·· ·ble sum rule for unfavorable deviations, and a combin·.. or restriction of the maximum single deviation. The results indicate that the maximum deviation rule limits the variation between sound insulation and indices in a very efficient way.

82-2503

The Prediction of Sound Transmission through Buildings Using Statistical Energy Analysis

R J.M. Craik
Dept. of Building, Heriot-Watt Univ., Edinburgh, EH1 1HX, UK, J. Sound Vib., 82 (4), pp 505-516 (June 22, 1982) 13 figs, 15 refs

Key Words: Buildings, Sound transmission, Statistical energy analysis

Measurements were carried out on a building to evaluate the uses of statistical energy analysis for determining sound transmission performance. Coupling loss factors were measured and compared with predicted values. It was found that, in general, good agreement was obtained. The coupling loss factors were also used to calculate the sound pressure level, or surface velocity, of each subsystem in the building for a number of different sources. Comparison with the measured results gave an average error of 4 dB.

82-2504

Understanding Noise Control, Part II. Principles and Procedures for Reducing Exterior Noise

R. Moulder
Acoustical Res. Lab., Owens-Corning Fiberglass Corp., Granville, OH, Plant Engrg., pp 57-58 (Sept 2, 1982) 4 figs

Key Words: Buildings, Noise reduction

Means for controlling structure-borne and airborne exterior noise in buildings are described.

82-2505

Identification of Cladding-Structure Interaction in Highrise Buildings Using Parameter Estimation Methods

M. Meyyappa
Ph.D. Thesis, Georgia Inst. of Tech., 212 pp (1982)
DA8215266

Key Words: Buildings, Multistory buildings, Cladding effect, Parameter identification technique

The influence of cladding on the dynamic response of two highrise buildings is investigated by studying its effect on the modal parameters. Ambient tests conducted in one of the buildings at different stages of construction during installation of cladding are described. The estimation of modal parameters from output data is carried out by curve fitting the analytical form of magnitude of the frequency response function to the measured response Fourier amplitude spectra, using the least squares criterion. An attempt is made to correlate the observed changes in the modal parameters with construction to the amount of cladding that had been installed on various test dates. It is noted that the effect of cladding could be to increase the frequencies of the higher modes slightly. The second building is used to evaluate the cladding performance analytically.

82-2506

Dynamic Characteristics of Coupled Wall-Frame Systems

A.K. Basu and G.Q. Dar
Indian Inst. of Tech., Delhi, India, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 615-631 (July/Aug 1982) 20 figs, 6 refs

Key Words: Buildings, Multistory buildings, Natural frequencies, Mode shapes

The paper presents the first three natural frequencies and the corresponding mode shapes for fixed-base multistory buildings which can be idealized as an equivalent planar coupled shear wall connected in series to an equivalent frame. The coupled wall is modeled as a continuum of uniform properties and the frame as a uniform shear beam, the connection between the two elements being taken as continuous. Solutions are obtained by treating the structure as a lumped parameter system with twenty equidistant discrete masses having only translational inertia. The relevant flexibility matrix is, however, generated from the exact solution of the governing differential equation for the continuum subjected to point loading. The results are presented for various combinations of the three non-dimensional parameters which are sufficient to describe all the geometric and materia' ropperties of the system.

82-2507

Eccentric Bracing in Tall Buildings

A.T. Merovich, J.P. Nicoletti, and E. Hartle
John A. Blume and Assoc., Engrs., 130 Jessie St., San Francisco, CA 94105, ASCE J. Struc. Div., 108 (9), pp 2066-2080 (Sept 1982) 10 figs, 4 tables, 11 refs

Key Words: Buildings, Multistory buildings, Seismic design, Braces

Primary concerns in the design of high-rise buildings, particularly those located in seismically active regions, are the control of interstory drift and the ability of the structure to withstand inelastic deformations. This paper describes how an eccentric bracing scheme was used to satisfy the requirements for both drift control and ductility in the design of a high-rise structure located in a zone of high seismic exposure.

82-2508

Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Wall Testing, Out-of-Plane

ABK, El Segundo, CA, Rept. No. ABK-TR-04, 382 pp (Aug 1981)
PB82-213687

Key Words: Buildings, Masonry, Seismic design, Dynamic tests, Walls

This report describes an experimental program conducted on unreinforced masonry walls subjected to dynamic, out-of-plane motions. The experimental program is one of several tasks in an overall research program, sponsored by the National Science Foundation, whose objective is to develop a methodology for mitigation of seismic hazards in existing unreinforced masonry buildings.

82-2509

Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings: Diaphragm Testing

ABK, El Segundo, CA, Rept. No. ABK-TR-03, 445 pp (Dec 1981)
PB82-213679

Key Words: Buildings, Masonry, Seismic design, Dynamic tests

This report describes an experimental program conducted on horizontal diaphragms subjected to quasi-static, cyclic, in-plane displacement and dynamic, in-plane earthquake shaking. The experimental program is one of several tasks in an overall research program, sponsored by the National Science Foundation, whose objective is to develop a methodology for mitigation of seismic hazards in existing unreinforced masonry buildings.

TOWERS

82-2510

Analyses of Cooling Tower Dynamics

R.L. Nelson

Central Electricity Res. Labs., Central Electricity Generating Board, Leatherhead KT22 7SE, UK, J. Sound Vib., 79 (4), pp 501-518 (Dec 22, 1981) 3 figs, 8 tables, 22 refs

Key Words: Towers, Cooling towers, Chimneys, Vibration analysis, Seismic excitation, Wind-induced excitation, Finite element technique

A finite element method for analyzing accurately the free vibrations of cooling towers (with column-supports) is shown to give results that are in good agreement with the experimental data obtained on both a full scale cooling tower and the corresponding model structure. The theoretical method is also used successfully to explain the apparent discrepancies between the respective experimental results obtained for both model and full scale structures. The effect of foundation elasticity can be included in the method and it is shown to have a significant effect on the lower modes of a cooling tower. The usefulness of the method as a design tool is demonstrated, and as an example, the effects of changing the dimensions of the cornice, ring-beam and column-supports are studied.

82-2511

Natural Frequencies of Cooling Tower Shells

C.R. Calladine

Dept. of Engrg., Univ. of Cambridge, Cambridge CB2 1PZ, UK, J. Sound Vib., 82 (3), pp 345-369 (June 8, 1982) 12 figs, 2 tables, 16 refs

Key Words: Towers, Cooling towers, Shells, Natural frequencies

Approximate explicit formulae are presented for the fundamental natural frequency of vibration of a uniform hyperboloidal cooling tower shell mounted on a rigid base, and for the circumferential wavenumber associated with fundamental mode. These formulae agree well with results previously obtained by finite element computation and they may be adapted readily for use with cooling tower shells mounted on non-rigid supports. The simplicity of the formulae is a consequence of various approximations which are made in the analysis.

82-2512
Studies of Dynamic Response of a Guyed Tower
G.R. Darbre
Ph.D. Thesis, Rice Univ., 486 pp (1982)
DA8216308

Key Words: Towers, Guyed structures, Off-shore structures, Cables

The objective of this investigation was to contribute to improved understanding of the dynamic response of off-shore guyed towers. This was accomplished through studies of the following interrelated problems: effects of cable and foundation constraints on the natural frequencies and modes of vibration of representative structural systems; low-amplitude harmonic stiffness and free vibrational characteristics of inclined parabolic cables; effects of cable-tower interaction on the dynamic response of the tower; and response of representative guyed tower models to simulated wave loadings.

FOUNDATIONS

82-2513
An Analytical Method to Determine the Underground-Coupling Between Rigid Strip-Foundations Bonded to the Surface of a Half-Space Subjected to Harmonic Excitation (Ein analytisches Verfahren zur Berechnung der Untergrundkopplung von mehreren starren, auf der Halbraumoberfläche liegenden Streifenfundamenten bei harmonischer Erregung)
Th. Triantafyllidis
Inst. f. Bodenmechanik und Felsmechanik der Universitat Karlsruhe, Kaiserstrasse 12, D-7500 Karlsruhe, Bundesrepublik Deutschland, Ing. Arch., 52 (3/4), pp 145-157 (1982) 5 figs, 17 refs
(In German)

Key Words: Interaction: soil-foundation, Half-space, Harmonic excitation

A finite number of dynamically coupled rigid strip foundations is considered, which are perfectly bonded to the surface of a linear-elastic isotropic and homogeneous half space, representing a mixed two-dimensional boundary value problem. The resulting loads between the rigid inertialess strip foundations and the half space due to harmonic displacement excitation are calculated. The mixed boundary value problem is transformed into a system of coupled Fredholm integral equations of the first kind, the kernels being the unknown surface stresses under the foundations. An approximate solution of the integral equations is obtained using the generalized Bubnov-Galerkin method. It is demonstrated that the results provide a simple means for studying the motions of a finite number of adjacent foundations with varying inertia properties.

CONSTRUCTION EQUIPMENT

82-2514
Finite Element Analysis of Soil Compaction Resulting from Vibratory Tillage
H. Vazin
Ph.D. Thesis, The Univ. of Tennessee, 93 pp (1982)
DA8215405

Key Words: Agricultural machinery, Soil compacting, Finite element technique

Factors governing performance of a vibratory plow are vibration frequency, amplitude and direction, speed, and angle and shape of the plow blade. Soil is assumed to be a linearly elastic, isotropic, homogeneous, and layered medium. A finite element mesh was selected to represent the soil. To idealize the action of a vibratory plow in soil, sinusoidal forcing function was applied to the mesh. Compaction of the selected area of the mesh under the action of the forcing function then was taken as a means of representing compaction of the soil under the action of a vibratory plow. This analysis was performed for vertical and horizontal directions of the forcing function, idealizing vertical and horizontal directions of vibration of the plow. To verify results obtained from the model, a vibratory plow with the capability of vibrating in either a horizontal or vertical direction, along with the capacity of providing a frequency range of 0-50 Hz and an amplitude range of 0-25 mm, was designed and constructed. The plow was tested in a field with soil having the same parameters used in the model analysis.

POWER PLANTS

82-2515
Computerized Method for Estimation of the Frequency Response of a Nuclear Reactor
F. Baldeweg and G. Steingroewer
Zentralinstitut f. Kernforschung, Rossendorf bei Dresden, German Dem. Rep., 8 pp (Feb 1981)
ZfK-435
(In German)

Key Words: Nuclear reactors, Frequency response, Computer-aided techniques, Periodic excitation

A computerized method for the measurement of the frequency response of nuclear reactors is described. The sinusoidal input signal is realized by computer control of the automatic controller. The upper frequency limit is given by the inertness of the control rod system.

OFF-SHORE STRUCTURES

82-2516

Wave Loading on Offshore Structures: A Review

R.G. Standing

National Maritime Inst., Feltham, UK, Rept. No. NMI-R-102, OT-R-8113, 142 pp (Feb 1981)

N82-21554

Key Words: Off-shore structures, Wave forces, Cylinders, Fatigue life

Research relevant to design, particularly of deep water structures, is reviewed. Morison's equation and forces on tubular members obtained from large scale experiments in the laboratory and at sea are discussed. Effects of marine growth and surface roughness, slamming on horizontal members, and vortex shedding (including lift forces) are considered. The wave diffraction method for estimating wave loads on members of large diameter and unusual shape and second order wave drift forces, affecting the low frequency response of structures and mooring loads, are included. Structural response and probabilistic methods, which are assuming a greater importance as dynamic loading and fatigue become more critical in design, are also covered.

82-2517

Dynamics of Offshore Structures, Part 1: Perturbation Analysis

R. Eatock Taylor and A. Rajagopalan

Dept. of Mech. Engrg., Univ. College London, London WC1E 7JE, UK, J. Sound Vib., 83 (3), pp 401-416 (Aug 8, 1982) 7 figs, 1 table, 12 refs

Key Words: Off-shore structures, Perturbation theory

An assessment of the nonlinear effects implied by the modified Morison equation is made and a spectral approach is adopted. The wave excitation is taken as a nonlinear function of the Gaussian wave kinematics, while the implied hydrodynamic damping is taken to be linear but time varying. The solution is obtained by a perturbation technique. Results are compared with those of linearization and time domain simulation. The appearance of higher order convolutions of the wave spectra in the present approach leads to increased excitation near the fundamental natural frequency of typical space frame structures, in comparison with linear solutions. The implied hydrodynamic damping, however, plays a major part in limiting resonant responses.

82-2518

Dynamics of Offshore Structures, Part II: Stochastic Averaging Analysis

A. Rajagopalan and R. Eatock Taylor

Dept. of Mech. Engrg., Univ. College London, London WC1E 7JE, UK, J. Sound Vib., 83 (3), pp 417-431 (Aug 8, 1982) 3 figs, 3 tables, 6 refs

Key Words: Off-shore structures, Stochastic processes, Statistical analysis

This paper is concerned with an investigation into the nonlinear dynamics of drag dominated offshore structures excited by waves. The equations of motion are approximated by a linear system with a time varying damping term; the excitation however is a nonlinear function of the wave particle kinematics. To study the effect of the time varying damping, the resonant response is examined by means of a narrow band idealization. A stochastic averaging of the governing equations is applied, and the Fokker-Planck equation for the response amplitude probability densities is thereby obtained. From the stationary solution of this equation, second order statistics are derived, together with an expression for the hydrodynamic damping which is equivalent to the time varying term. Numerical results are given to illustrate the magnitude of this term for a typical framed structure, and to provide comparisons with results obtained by the conventional technique of linearization.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 2543, 2546, 2600, 2648)

82-2519

The Department of Transpc... Attitude Towards Road Noise

R.A.F. Smith, R. Hales, and P.G. Fanner

Dept. of Transport, Pretoria, South Africa, 18 pp (1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conference Ctr., Pretoria, Oct 21-23, 1981)
PB82-206079

Key Words: Traffic noise, Noise reduction, Regulations

The effects of transportation on the environment have caused problems which may be considered under two main headings -- those that arise from the impact of transport infrastructure and those that arise from the use of the infrastructure by vehicles -- fumes, vibration, noise and dirt. Transport policies in the major metropolitan areas of the Republic have been formulated around 4 main goals; namely, mobility, convenience for the user, reasonable costs and minimum side effects. From these goals each metropolitan transport area has formulated numerous objectives for the transport plan for the particular area.

82-2520

Traffic Noise Generation of Asphalt Road Surfaces

A.T. Visser and R.N. Walker

Natl. Inst. for Transport and Road Res., Pretoria, South Africa, 16 pp (Oct 1981) (Pres. at Inst. of Math. and its Appl. Conf. on Power from Sea Waves, Edinburgh, June 1979)
PB82-206053

Key Words: Traffic noise, Noise reduction, Regulations

Road traffic noise is becoming a matter of concern, particularly in the urban environment. The aim of this study was to evaluate the noise generating properties of different asphalt road surfacing types. Road surfacing type has a minor effect on the noise level inside vehicles at the higher speeds tested, but is more important at lower speeds. However, the surfacing type greatly determines the noise level measured alongside the road at low as well as high vehicle speeds. More noise is generated when the surface texture of surfacings that exhibit random asperities is increased.

82-2521

Traffic Noise Reduction by Means of Surface Wave Exclusion above Parallel Grooves in the Roadside

L.A.M. van der Heijden and M.J.M. Martens

Dept. of Botany, Experimental Ecology Section, Catholic Univ., Toernooiveld, 6525 ED Nijmegen, The Netherlands, Appl. Acoust., 15 (5), pp 329-339 (Sept 1982) 11 figs, 1 table, 18 refs

Key Words: Traffic noise, Noise reduction, Acoustic impedance, Noise barriers, Walls

A new method to reduce traffic noise by means of an invisible wall was investigated theoretically and experimentally. A formula was derived for the frequency dependent impedance of an infinite structure of parallel ribs on an impedance boundary. From the definition of surface waves it followed that these waves can only exist for certain combinations of frequencies, heights of ribs and phases of the complex reflection coefficient of the underlying surface. Upon making this surface softer, more low frequency sound is absorbed. Outdoor experiments above an array of 16 or 21 low brick walls showed a considerable absorption of sound.

82-2522

Sources of Brake Squeal in Motor Vehicles

R.K. Goatley

Ferodo (Pty) Ltd., Durban, South Africa, 14 pp (1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)
PB82-206145

Key Words: Brakes (motion arresters), Noise generation, Friction excitation

Squeal has been identified as a frictional vibration dependent on the coefficient of friction of the lining and its contact geometry. The mass and stiffness of related parts such as drum, shoe, and caliper, are contributory factors. Their influence on squeal in both disc and drum brake installations is discussed. Practical solutions to the problem are considered within limitations imposed by brake performance requirements.

82-2523

Motorcycle Noise - A Review of Current Practice

J. Venter

Pretoria Univ., South Africa, 10 pp (1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)
PB82-206061

Key Words: Motorcycles, Noise reduction

To keep the noise level as low as possible a motorcycle designer has a number of conflicting requirements to consider and this paper investigates some of these parameters. The serious problem of the noise-polluting effect of non-standard exhaust systems is examined and an enforcement solution is suggested.

82-2524

Performance Limits of Rail Passenger Vehicles: Conventional, Radial and Innovative Trucks

J.K. Hedrick, D.N. Wormley, R.R. Kim, A.K. Kar, and W. Baum

Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. DOT/RSPA/DPB-50/81/28, 239 pp (Mar 1982)

PB82-202466

Key Words: Trucks, Ride dynamics, Stability, Cornering effects

The dynamic performance capability of conventional, radial, and innovative passenger trucks is identified and optimized with respect to ride quality, stability, and curve negotiation.

82-2525

Comparative Investigation of Vehicle Vibrations on Three-Dimensional Vehicle Models (Vergleichende Untersuchung von Fahrzeugschwingungen an räumlichen Ersatzmodellen)

E. Kreuzer and G. Rill

Inst. B f. Mechanik, Universität Stuttgart, Pfaffenwaldring 9, D-7000 Stuttgart 80, Bundesrepublik Deutschland, Ing. Arch., 52 (3/4), pp 205-219 (1982) 9 figs, 2 tables, 13 refs

(In German)

Key Words: Ground vehicles, Interaction: road-vehicle, Mathematical models, Stochastic processes

An exact simulation of vehicle vibrations can only be done with three-dimensional models. In this paper four vehicle models of different complexity and excited stochastically by means of an appropriately modeled three-dimensional roadway are investigated. It is shown how variations in modeling produce different ride comfort and ride safety criteria.

82-2526

The Effects of Track Modulus on Vehicle-Track Dynamic Interaction

D.R. Ahlbeck

Battelle Columbus Labs., Columbus, OH, ASME Paper No. 82-RT-3

Key Words: Interaction: rail-vehicle

Track dynamic modulus has long been recognized as an important factor in rail vehicle ride quality and operating safety. A qualitative definition of track dynamic modulus is presented in this paper, along with numerical values based on recent laboratory and field measurement experiments. Results from mathematical models using these values are presented to explore vehicle-track dynamic interactions.

82-2527

Validating Rail Vehicle Dynamic Models: A Case Study

A. Gilan and J.K. Hedrick

Raphael, Haifa, Israel, ASME Paper No. 82-RT-6

Key Words: Railroad cars, Interaction: rail-vehicle

This paper describes the evaluation of lateral tangent track dynamic models by comparing them to experimental data. The models were developed to predict the response of conventional and self-steering radial passenger trucks to random alignment and cross-level track irregularities.

82-2528

Estimation and Control of Ground Vibrations from Trains on Concrete Elevated Structures

D.A. Towers

Bolt, Beranek and Newman Inc., 10 Moulton St., Cambridge, MA 02238, Noise Control Engrg., 19 (1), pp 26-33 (July-Aug 1982) 7 figs, 8 refs

Key Words: Ground vibration, Railroad trains, Traffic-induced vibrations, Elevated railroads, Rapid transit railways

Concrete elevated structures currently make up approximately 48 km (30 route miles) of all newer US urban rail transit systems. The proposed Metropolitan Dade County (Miami) Rapid Transit System will include an additional 32 km (20 miles) of concrete elevated guideway, passing near potentially vibration sensitive areas such as residences, hospitals and research buildings. The estimation and control of ground vibration from the proposed system elevated structures are based on measurements conducted at the Port Authority Transit Corporation (PATCO) rail transit system in Camden County, New Jersey. Future ground vibrations were estimated by adjusting the PATCO measurement results for small differences in system-specific parameters. The results provide a basis for the evaluation of practical vibration control design alternatives.

SHIPS

82-2529

Fluid/Structure Interaction Analysis in the Consideration of Directivity Patterns of Hull-Mounted Transducers

B.E. Sandman, A. Harari, and J.S. Griffin

Naval Underwater Systems Ctr., Newport, RI 02840, J. Acoust. Soc. Amer., 72 (2), pp 625-632 (Aug 1982) 5 figs, 9 refs

Key Words: Transducers, Interaction: structure-fluid, Ship hulls, Submerged structures, Shells, Cylindrical shells

For an acoustic transducer mounted on the exterior of a submerged hull structure, the effect of dynamic hull mobility upon directivity patterns is a subject of considerable interest to array design engineers. Cylindrical geometry, mounting point impedance, and structural dispersion are possible significant factors in beam pattern distortion. This analytical study utilizes a fundamental fluid/structure interaction model of submerged cylindrical shells to investigate the role of hull vibrations induced by the reactive excitation of a transducer element. It is shown that hull vibration can alter a single-element directivity pattern significantly. The model employed for this study possesses sufficient generality to consider the additional effects of hull damping, transducer isolation, and array beam forming.

AIRCRAFT

(Also see Nos. 2553, 2554, 2555, 2560)

82-2530

Trailing-Edge Noise from Hovering Rotors

Y.N. Kim and A.R. George

Cornell Univ., Ithaca, NY, AIAA J., 20 (9), pp 1167-1174 (Sept 1982) 7 figs, 34 refs

Key Words: Rotors, Helicopters, Noise prediction

A method has been developed to predict the high-frequency broadband noise due to the interaction of convecting turbulent eddies with the trailing edges of a hovering rotor. The trailing-edge noise from each blade was modeled as moving point dipole noise with spanwise loading corrections. This point dipole approximation was checked by applying the concept to a stationary airfoil in a moving medium with excellent results. In order to estimate the strength of the point dipole, the trailing-edge noise theory of Amiet was used. The method was applied specifically to blade boundary-layer turbulence and compared to incident atmospheric turbulence noise. The results indicate that the relative importance of these two mechanisms is related to the intensities and the magnitudes of the length scales of the inflow and boundary-layer turbulence.

82-2531

Acoustic Evaluation of the AGUSTA 109A Helicopter in Compliance with the Proposed ICAO Annex 16/Chapter 8 Regulations

W.R. Splettstoesser and S.R. Nagaraja

Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt e.V., Brunswick, Fed. Rep. Germany, Rept. No. DFVLR-MITT-81-24, 122 pp (Sept 1981) N82-22993

(In German)

Key Words: Helicopter noise, Noise measurement, Regulations

Noise measurements on the AGUSTA 109A helicopter were performed in order to determine the effective perceived noise levels (EPNL) in compliance with proposed regulations, investigate flight altitu 's effects on EPNL, and evaluate the effect of different takeoff power settings on EPNL. EPNL values for operational modes are close to the proposed noise limits.

82-2532

Ground Reflection Effects in Measuring Propeller Aircraft Flyover Noise

W. Dobrzynski

Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt e.V., Brunswick, Fed. Rep. Germany, Rept. No. DFVLR-FB-81-28, ESA-TT-742, 85 pp (Aug 1981)

N82-22990

(In German)

Key Words: Aircratt noise, Measurement techniques, Ground effect

In measuring flyover noise for purposes of propeller aircraft noise certification, microphones are positioned 1.2 m above the ground. The influence of ground reflection on the maximum A weighted aircraft noise level was investigated. Ground reflection induces level differences of up to 3 db (A), depending on rotational speed and number of blades. Since reflection corrections cannot successfully be applied to propeller noise signatures, alternative measuring arrangements, such as microphones in close proximity to the ground, were investigated.

82-2533
Recommendations for Field Measurements of Aircraft Noise
A.H. Marsh
DyTec Engrg., Inc., Long Beach, CA, Rept. No. NASA-CR-3540, 94 pp (Apr 1982)
N82-22955

Key Words: Aircraft noise, Measurement techniques, Noise measurement

Specific recommendations for environmental test criteria, data acquisition procedures, and instrument performance requirements for measurement of noise levels produced by aircraft in flight are provided. Recommendations are also given for measurement of associated airplane and engine parameters and atmospheric conditions. Recommendations are based on capabilities which were available commercially in 1981; they are applicable to field tests of aircraft flying subsonically past microphones located near the surface of the ground either directly under or to the side of a flight path. Aircraft types covered by the recommendations include fixed-wing airplanes powered by turbojet or turbofan engines or by propellers. The recommended field-measurement procedures are consistent with assumed requirements for data processing and analysis.

82-2534
Aerodynamic Noise Generated by Jet-Wing/Flap Interactions of the External USB Configuration of STOL Aircraft. Part 1: Eight Percent Scale Cold-Flow Model Analysis
M. Maita and S. Shindo
Natl. Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-685T, 29 pp (Oct 1981)
N82-22953

Key Words: Aircraft noise, Noise reduction

The acoustic characteristics of the external upper surface blowing (USB) concept of a powered high lift system (PHLS) were studied experimentally using an 8%-scale static cold flow model. Observations of exhaust jet flow attachment and spreading characteristics on wing/flap surface were also carried out using several flow visualization techniques. Noise reduction data were obtained by optimizing basic jet nozzle wing/flap structural geometries for the lowest noise.

82-2535
Analytical Prediction of the Interior Noise for Cylindrical Models of Aircraft Fuselages for Prescribed Exterior Noise Fields. Phase 2: Models for Sidewall Trim, Stiffened Structures and Cabin Acoustics with Floor Partition
L.D. Pope and E.G. Wilby
Bolt, Beranek and Newman, Inc., Canoga Park, CA, Rept. No. NASA-CR-165869, 212 pp (Apr 1982)
N82-22952

Key Words: Aircraft noise, Noise prediction, Interior noise

An airplane interior noise prediction model is developed to determine the important parameters associated with sound transmission into the interiors of airplanes, and to identify appropriate noise control methods. Models for stiffened structures and cabin acoustics with floor partition are developed. Validation studies are undertaken using three test articles: a ring stringer stiffened cylinder, an unstiffened cylinder with floor partition, and ring stringer stiffened cylinder with floor partition and sidewall trim.

82-2536
Development and Validation of Preliminary Analytical Models for Aircraft Interior Noise Prediction
L.D. Pope, D.C. Rennison, C.M. Willis, and W.H. Mayes
Bolt, Beranek and Newman, Inc., Canoga Park, CA 91305, J. Sound Vib., 82 (4), pp 541-575 (June 22, 1982) 18 figs, 7 tables, 19 refs

Key Words: Aircraft noise, Interior noise, Noise prediction

A preliminary version of an airplane interior noise prediction model has been developed. This model is based on a power flow type of analysis. For validation of the model, predictions are made of the sound transmission into a simple unpressured, unstiffened cylinder under random and harmonic excitations. These are compared against experimental results and statistically significant differences between predictions and measurements are identified. It is concluded that these differences are related primarily to input data deficiencies.

82-2537
Recent Research on Noise Transmission into Aircraft
R. Vaicaitis
Inst. of Flight Structures, Columbia Univ., New York, NY 10027, Shock Vib. Dig., 14 (8), pp 13-18 (Aug 1982) 85 refs

Key Words: Aircraft, Interior noise, Noise transmission, Reviews

This paper surveys literature concerning noise transmission prediction into aircraft. Papers from 1960 through early 1982 are reviewed. Special attention is given to noise transmission and cabin noise optimization for a propeller driven aircraft.

82-2538

Flutter and Oscillatory Pressure Tests on a 727 Aileron in a Wind Tunnel

K.S. Nagaraja, G.C. Lakin, and J.B. Bartley

Boeing Commerical Airplane Co., Seattle, WA, J. Aircraft, 19 (9), pp 781-786 (Sept 1982) 14 figs, 3 refs

Key Words: Aircraft wings, Flutter, Wind tunnel testing

This paper presents the subcritical flutter characteristics of a rigid, full-scale 727 wing segment with inboard aileron and tab that was tested in a low-speed wind tunnel. The airplane lateral control svstem was simulated, and testing was performed with and without the internal pressure balance panel. Subcritical damping characteristics of the binary flutter mode were measured for three cases of tab mass balance and compared with analyses. In addition, oscillatory pressures in the region of the control surface and aileron hinge moments were measured for a wide range of reduced frequencies.

82-2539

Experiment on Active Flutter Suppression of a Cantilever Wing

T. Kikuchi and H.K. Lee

Natl. Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-690, 10 pp (Dec 1981)

N82-22282

(In Japanese)

Key Words: Aircraft wings, Active flutter control, Flutter, Cantilever plates

An experiment on active flutter suppression of a cantilever wing with the control surface at the wing tip is described. The experiment was done in a low subsonic wind tunnel. The deflection of the wing was measured by strain gages located near the root of the wing. The aileron was driven by a servomotor. Comparison was made between the present and previous results.

82-2540

Crashworthiness Studies: Cabin, Seat, Restraint, and Injury Findings in Selected General Aviation Accidents

W.R. Kirkham, S.M. Wicks, and D.L. Lowrey

Office of Aviation Medicine, Fed. Aviation Administration, Washington, DC, Rept. No. FAA-AM-82-7, 24 pp (Mar 1982)

AD-A114 878

Key Words: Crash research (aircraft), Crashworthiness

This report reviews 47 survivable or partly survivable accidents investigated since 1973 by personnel from the Civil Aeromedical Institute. The accidents were reviewed for a number of features of crashworthiness and, in particular, for injuries to occupants in relation to the severity of the impact and the performance of cabin and restraint systems. Opinions were rendered by trained crash injury investigators as to the role or expected role in seats and upper torso restraints in adding to or lessening the injuries. The data support the general concepts that nonoccupiable portions of the aircraft receive greater physical damage than occupiable areas.

MISSILES AND SPACECRAFT

82-2541

Analytical and Experimental Evaluations of Space Shuttle TPS Tile Vibration Response

A.G. Piersol and L.D. Pope

Bolt, Beranek and Newman, Inc., Canoga Park, CA 91303, J. Sound Vib., 83 (1), pp 37-51 (July 8, 1982) 11 figs, 2 tables, 3 refs

Key Words: Space shuttles, Thermal protection systems (spacecraft), Tiles, Acoustic excitation, Vibration response

Analytical studies and laboratory experiments have been performed to evaluate the vibration response of the space shuttle thermal protection system (TPS) tiles due to the intense rocket generated acoustic noise during lift-off. The TPS tiles are mounted over the exterior of the space shuttle orbiter structure through strain isolation pads (SIP) which protect the tiles from thermal induced shear loads at their interface. The analytical predictions indicate that the response of a typical tile is governed by the structural vibration inputs through the SIP under the tile at frequencies below 150 Hz, and by the direct acoustic excitation over the exterior surface of the tile at frequencies above 250 Hz.

BIOLOGICAL SYSTEMS

HUMAN

82-2542
Subjective Responses of Chinese to Aircraft Noise
N.W.M. Ko and P.C.K. Lei
Dept. of Mech. Engrg., Univ. of Hong Kong, Hong Kong, Appl. Acoust., 15 (4), pp 251-261 (July 1982) 6 figs, 3 tables, 14 refs

Key Words: Aircraft noise, Human response

A social study was undertaken of the subjective responses to aircraft noise of 909 Chinese in Hong Kong. The study population lives near, or adjacent to, the flight-paths of aircraft landing at, or taking off from, the international airport of Kai Tak. The subjective responses of the Chinese correlate well with the Noise and Number Index. Comparisons of the responses of the Chinese group with those of teachers and firemen in the city and with Londoners have been attempted.

82-2543
Aspects of Train Noise in South Africa
H.R. Raad
Council for Scientific and Industrial Res., Pretoria, South Africa, 30 pp (1981)
PB82-204272

Key Words: Railroad trains, Noise generation, Human response

A brief look is taken at the major sources of train noise including those from planned high speed trains. Factors affecting community response to train noise are discussed and some case histories of complaints concerning railway noise are presented. Possible implementations of control techniques to train noise are reviewed.

82-2544
Subjective Effects of Traffic Noise Exposure, II: Comparisons of Noise Indices, Response Scales, and the Effects of Changes in Noise Levels
F.J. Langdon and I.D. Griffiths
Building Res. Establishment, Garston, Watford WD2 7JR, UK, J. Sound Vib., 83 (2), pp 171-180 (July 22, 1982) 1 fig, 6 tables, 15 refs

Key Words: Traffic noise, Urban noise, Human response

Traffic noise and social surveys were carried out at eight London suburban sites. Dwellings at the selected sites were exposed to noise from freely flowing traffic at various levels. The study was designed to obtain noise measurements and subjective responses from residents on four repeated occasions throughout the year.

82-2545
Community Noise Impact Indicators: A Framework with Examples
M. Maurin
Inst. de Recherche des Transports, Centre d'Evaluation et de Recherche des Nuisances et de l'Energie, 69672 Bron Cedex, France, J. Sound Vib., 79 (4), pp 479-499 (Dec 22, 1981) 11 figs, 5 tables, 26 refs

Key Words: Traffic noise, Human response

Road traffic noise is widely spread in urban areas resulting in an acoustic impact on the whole population. When different conditions of this situation (action on traffic, road networks, buildings, etc.) are changed, each person's exposure changes and a new situation with a new impact is obtained. The objective is to obtain means to estimate the impacts, the importance of changes and even the evolution of collective acoustic situations, and to improve the general exposure as well as that in the noisiest cases. In this paper a sequence of such tools is examined, with emphasis on different ways of data presentation and essential steps in the collection and processing of the data relative to noise and the exposed population.

82-2546
Occupant Survivability in Heavy-Truck Crashes
B. Wolf, K.L. Campbell, and J. O'Day
Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI, Rept. No. UM-HSRI-81-55, MVMA-1164, 31 pp (Nov 1981)
PB82-202383

Key Words: Collision research (automotive), Trucks, Safety restraint systems, Seat belts

Rollover and ejection are associated with heavy-truck occupant fatalities about twice as frequently as for passenger-car occupant fatalities. A panel reviewed 41 in-depth cases to assess the possible effectiveness of restraint use and the contribution of rollover and ejection to the fatal injuries. The panel's responses indicated that belt use was expected to be particularly effective in preventing fatalities resulting from occupant ejection.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see No. 2584)

82-2547

A Lumped Parameter Model for the Iterative Analysis of Cylinderlike Antivibration Mounts

C. Ianniello and L. Maffei
Istituto di Fisica Tecnica, Facolta di Ingegneria, Universita di Napoli, 80125 Napoli, Italy, J. Acoust. Soc. Amer., 72 (2), pp 482-487 (Aug 1982) 6 figs, 3 refs

Key Words: Mountings, Vibration isolation, Elastomers, Dynamic stiffness, Stiffness coefficients, Damping coefficients, Lumped parameter method

It is known that wave effects in antivibration mounts result in differences between the force transmissibility, calculated for a one-degree-of-freedom system having constant spring and dashpot parameters, and the experimentally measured one. An evaluation method which allows one to obtain the above mentioned parameters as functions of the frequency for simple rubber systems is presented. The method takes into account the high-frequency interaction between the distributed mass and elasticity which is responsible for the wave effects in the mount. Some experimental evidence about the validity of the method is given.

82-2548

Lead-Rubber Hysteretic Bearings Suitable for Protecting Structures During Earthquakes

W.H. Robinson
Physics and Engrg. Lab., Dept. of Scientific and Industrial Res., Lower Hutt, New Zealand, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 593-604 (July/Aug 1982) 14 figs, 1 table, 20 refs

Key Words: Base isolation, Buildings, Elastomeric bearings, Bearings

Lead-rubber hysteretic bearings provide in a single unit the combined features of vertical load support, horizontal flexibility and energy absorbing capacity required for the base isolation of structures from earthquake attack. The lead-rubber hysteretic bearing is a laminated elastomeric bearing of the type used in bridge structures, with a lead plug down its center. This paper describes the tests on the lead-rubber bearings, the results and a design procedure for selecting the size of the lead plug.

SPRINGS

82-2549

Sizing Torsional Leaf Springs

R. Lilliston
Martin Marietta Aerospace, Orlando, FL, Mach. Des., 54 (15), pp 67-71 (June 24, 1982) 3 figs, 3 refs

Key Words: Leaf springs, Torsion bars, Design procedures

Design calculations for torsional leaf springs are presented. The procedure applies only to blades having identical dimensions, but it is more straightforward than the procedure described in SAE manual for leaf springs consisting of blades with either the same or different widths and thicknesses.

82-2550

On the Dynamic Behaviour of Axially Excited Helical Springs

L.D. Pietra and S.D. Valle
Istituto di Meccanica applicata, Univ. of Naples, Naples, Italy, Meccanica, 17 (1), pp 31-43 (Mar 1982) 11 figs, 2 tables, 8 refs

Key Words: Springs, Helical springs, Natural frequencies

Wittrick's theory on the propagation of deformation waves in a coiled wire is used -- taking into account only the coupling between the displacements of the wire cross-section along the tangent and along the binormal of the average helix -- in order to show how the natural frequencies of the axial and rotational modes of a cylindrical helical spring vary according to a nonlinear function of the wave number. It

is also demonstrated that the natural frequencies resulting from the proposed theory for the natural modes, to which correspond wave lengths greater than two coils, do not differ much from those which can be calculated by considering the spring as a periodic discrete system. Theoretical results are finally tested by an appropriate experimental investigation.

TIRES AND WHEELS

82-2551

Tire/Road Noise

G.J. Kind

Goodyear Intl. Tire Technical Ctr., Luxembourg, 22 pp (1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)

PB82-206137

Key Words: Tires, Noise generation, Interaction: tire-pavement, Noise measurement

This paper discusses the different mechanisms that are at the origin of tire to surface noise. Various tire noise measurement and analysis techniques are described and analyzed regarding their correlation to subjective testing. Means to reduce tire noise are proposed and discussed in the context of other important tire properties.

BLADES

82-2552

Analysis of Lateral Vibrations of Rotating Cantilever Blades Allowing for Shear Deflection and Rotary Inertia by Reissner and Potential Energy Methods

K.B. Subrahmanyam, S.V. Kulkarni, and J.S. Rao

Dept. of Mech. Engrg., Regional Engrg. College, Kurukshetra, India, Mech. Mach. Theory, 17 (4), pp 235-241 (1982) 3 figs, 4 tables, 30 refs

Key Words: Blades, Cantilever plates, Rotating structures, Lateral vibration, Transverse shear deformation effects, Rotatory inertia effects

The lateral vibrations of a uniform rotating blade have been analyzed applying the Reissner and the potential energy methods. Shear deflection and rotary inertia are taken into account. A convergence study of the two methods is made and the effects of shear deflection, rotary inertia, rotation and stagger angle on the blade vibration characteristics are discussed. Comparison of the results indicates a quicker convergence and better mode shapes by the Reissner method than the classical potential energy method.

82-2553

Tail Rotor Studies for Satisfactory Performance: Strength and Dynamic Behavior

G. Blachere and F. Dambra

Societe Nationale Industrielle Aerospatiale, Marignane, France, Rept. No. SNIAS-821-210-108, 13 pp (1981) (Pres. at 7th European Rotorcraft and Powered Lift Aircraft Forum, Garmisch-Partenkirchen, W. Germany, Sept 8-11, 1981)

N82-22258

Key Words: Blades, Rotors, Propeller blades, Helicopters

Flexbeam, teetered, cantilevered and semirigid two bladed rotors were studied in flight, on whirl test stands and theoretically. The blades are compared with conventional helicopter blades. For 2 ton helicopters, the tested blades have fewer parts, and weigh less than conventional ones. Blade life is increased, manufacturing and maintenance costs are lowered. For 8 ton helicopters, similar improvements were achieved, but at the expense of larger control forces and limited lifetime for the flexbeam.

82-2554

A Complete Method for Computation of Blade Mode Characteristics and Responses in Forward Flight

J.P. Lefrancq and B. Masure

Societe Nationale Industrielle Aerospatiale, Marignane, France, Rept. No. SNIAS-821-210-101, 10 pp (1981) (Pres. at 7th European Rotorcraft and Powered Lift Aircraft Forum, Garmisch-Partenkirchen, W. Germany, Sept 8-11, 1981)

N82-22254

Key Words: Blades, Propeller blades, Rotors, Modal analysis

The modal approach to rotor dynamic behavior is outlined, and an azimuth method is presented. The azimuth method applies to stabilized flights, in particular those in which rotor configuration is considered repeatable after one revolution.

82-2555

Helicopter Rotor Blade Tips (Les Extremities de Pales d'Helicopteres)

R. Lyothier

Assn. Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-81-19, 25 pp (Nov 1981)

PB82-213455

(In French)

Key Words: Blades, Rotor blades (turbomachinery), Helicopters, Rotors, Noise reduction, Geometric effects

Appreciable improvement in the performance and vibration level of helicopters can be attained by means of rotor blade tips of particular shape. The principle involved is to reduce the extent of the supersonic zone which appears on the advancing blade as well as the vortex interaction. After a preliminary choice of shapes by calculation, measurements of performance and stresses were effected upon a rotor model of the most promising shape in the wind tunnel. The perceived parameters for most improved characteristics are the shape in plan to limit the supersonic zone and attenuate shock waves, and rotor twist and taper ratio to reduce the effects of vortex interaction.

82-2556

National Transonic Facility (NTF) Prototype Fan Blade Fatigue Test

E.H. Dean, A.J. Gustafson, and D.M. Saylor

Army Aviation Res. and Dev. Command, St. Louis, MO, Rept. No. USAAVRADCOM-TR-82-D-5, 18 pp (Mar 1982)

AD-A114 405

Key Words: Blades, Fan blades, Composite structures, Fatigue tests

Fatigue tests were conducted on a composite fan blade designed for use in the new NTF wind tunnel being constructed at NASA-Langley. The tests were performed using the root end fatigue machine which was modified for ground-air-ground testing. Simulated centrifugal and aerodynamic (bending) load tests were performed.

82-2557

Structural Dynamics of Shroudless, Hollow Fan Blades with Composite In-Lays

R.A. Aiello, M.S. Hirschbein, and C.C. Chamis

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1163, NASA-TM-82816, 12 pp (1982) (Pres. at 27th Ann. Intl. Gas Turbine Conf., London, Apr 18-22, 1982)

N82-22266

Key Words: Blades, Fan blades, Aircraft engines, Vibration analysis, Bird strikes, Computer programs

Structural and dynamic analyses are presented for a shroudless, hollow titanium fan blade proposed for future use in aircraft turbine engines. The blade was modeled and analyzed using the composite blade structural analysis computer program (COBSTRAN); an integrated program consisting of mesh generators, composite mechanics codes, NASTRAN, and pre- and post-processors. Vibration and impact analyses are presented.

82-2558

Alternating Stress Measurements on Model and Actual Turbine Blades

M. Glober and W. Maly

Rolls-Royce Ltd., Derby, UK, Rept. No. PNR-90101, TRANS-15784/TLT-00835, 28 pp (Sept 1981) (Pres. at 6th Intl. Conf. on Exptl. Stress Anal., 1978)

N82-22534

Key Words: Blades, Turbine blades, Natural frequencies, Measurement techniques

Methods of measuring the natural frequencies and dynamic stresses of axial turbine blades under operational conditions are described. Holographic interferometry, alternating stress distribution measurement, using strain gages, and natural frequency analysis on static blades and on rotating blades fitted with piezoelectric gages are discussed. Model turbines for determining nonsteady blade forces when guide vanes are partially impinged, a model of a low pressure turbine with trailer turbine, slip ring transmission measuring devices, and high frequency signal tests of blade vibration are treated.

82-2559

Measuring Rotating Blade Vibration of Large Low Pressure Steam Turbines

V. Donato, R.L. Bannister, and J.F. DeMartini

Westinghouse Electric Corp., PA, Chartered Mech. Engr., 28 (7), pp 46-49 (July 1981) 8 figs, 8 refs

Key Words: Blades, Turbine blades, Steam turbines, Vibration measurement

Turbine generators in operation today can generate more than 1300 MW or enough electricity to supply the residential needs of over four million people, so their reliability is of utmost importance in the economics of electrical energy generation. This article reviews the experimental techniques and instrumentation developments evolved over four decades by one turbine manufacturer to measure the dynamic behavior of rotating low pressure steam turbine blades.

FASTENERS

82-2560

Fatigue Behavior of Weldbonded Joints

G.V. Scarich and G.R. Chanani

Northrop Corp., Hawthorne, CA, J. Aircraft, 19 (9), pp 773-780 (Sept 1982) 14 figs, 7 tables, 7 refs

Key Words: Joints (junctions), Welded joints, Fatigue life, Aircraft

The efforts of material and process variables on fatigue behavior were determined for a newly developed, low-cost weldbounding process for the assembly of durable aircraft structures. The weldbonding process involves spot-welding components through a previously applied adhesive, and then oven-curing the assembly to achieve a bonded structure. Both *low-load and high-load transfer specimen geometries* with each of two alloy combinations were evaluated. Fatigue behavior of weldbonded specimens with different nugget sizes and different manufacturing defects was compared with that of riveted and adhesive-bonded specimens.

82-2561

Bolted Connections Dynamically Loaded in Tension

L.P. Bouwman

Dept. of Civil Engrg., Delft Univ. of Tech., Delft, The Netherlands, ASCE J. Struc. Div., 108 (9), pp 2117-2129 (Sept 1982) 15 figs, 2 refs

Key Words: Bolts, Bolted joints, Joints (junctions), Fatigue life

A report of fatigue tests on tensile loaded bolted connections is presented. The tests demonstrate clearly that the structural design is of major importance with regard to the fatigue strength of such connections. By designing connections which are structurally well-detailed, it is possible to eliminate entirely bolt fatigue in tension.

82-2562

Inelastic Cyclic Behavior of Steel Bracing Members

H. Gugerli

Ph.D. Thesis, Univ. of Michigan, 380 pp (1980) DA8215001

Key Words: Braces, Steel, Cyclic loading

The inelastic cyclic behavior of steel bracing members under severe axial deformation has been studied by several investigators in the past. To verify these results under more realistic conditions diagonally mounted members with rigid end connections were subjected to horizontal cyclic displacements. Nine commercially available wide-flange shapes and structural tubes with different slenderness and width-thickness ratios were tested. The influence of different cross sections was studied using an existing theoretical model with more realistic plasticity conditions at the location of plastic hinges.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

82-2563

In-Plane Vibrations of an Extensible and Flexible Chain of Particles: Application to a Thin and Curved Rod

P.-E. Ouellette

College de Saint-Laurent, Saint-Laurent, Quebec, Canada, J. Sound Vib., 83 (3), pp 379-399 (Aug 8, 1982) 11 figs, 5 tables, 11 refs

Key Words: Chains, Rods, Curved rods, Longitudinal vibration

The derivation of the exact normal modes of oscillation of a linear chain of N identical particles connected by identical springs (extensible chain), but with arbitrary springs connecting the end particles to rigid walls, is now classical. The corresponding analysis of the extensible polygonal chain, where the respective angles formed by the successive bonds are less than π, has not been previously done. It is realized here through the invention of an appropriate co-ordinate system where the position of each particle of the chain is determined by its respective distances to the equilibrium positions of the two nearest particles. As the straight extensible chain is a valid (if N tends to infinity) model of the straight, extensible and thin rod, the curved, extensible and

thin rod, can be viewed, in the limit, as a polygonal extensible chain. Therefore, through the limit process, its normal modes of oscillations can be derived. The consideration of a polygonal (or straight) chain which is flexible (existent elastic interaction between the adjacent bonds of the chain) is much more difficult. This is due to the presence of high order finite difference equations. However, the co-ordinate system used here permits, when the chain is closed (the *limit case being the thin ring), a complete treatment both* of the flexible chain and of the flexible and extensible chain.

CABLES

(Also see No. 2512)

82-2564

Analysis of Static and Dynamic Wind Tunnel Tests of the Shuttle Cable Trays

J.P. Reding and L.E. Ericsson
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA, J. Spacecraft, 19 (5), pp 412-418 (Sept-Oct 1982) 18 figs, 13 refs

Key Words: *Cables, Wind tunnel testing, Space shuttles*

Results of a study aimed at determining the possible aeroelastic instability of the Space Shuttle cable trays are presented. Cross flow over the trays, caused by unique flow interference effects, was found to be the potential source of the aeroelastic instability. Selected data from static and dynamic wind tunnel tests of cable tray sections, which furnished the essential input into the aeroelastic analysis, are presented and analyzed.

82-2565

Monofrequent Oscillations of a Non-Linear Model of a Suspended Cable

A. Luongo, G. Rega, and F. Vestroni
Instituto di Scienza delle Costruzioni, Universitá di Roma, Roma 00184, Italy, J. Sound Vib., 82 (2), pp 247-259 (May 22, 1982) 8 figs, 14 refs

Key Words: Cables, Two degree of freedom systems, Nonlinear theories

A two-degree-of-freedom nonlinear elastic model is considered to analyze the effects of nonlinearities on the free motion of a suspended cable. The discretized model is obtained by referring to simplified kinematics of the cable; the equations of motion which show quadratic and cubic nonlinearities are solved through the multiple time scale perturbation technique. The monofrequent oscillations of the system are studied in order to analyze the modification of frequency and motion amplitude of the modal oscillations *due to geometric nonlinearities in the absence of internal* resonance. The possibility that effects arise due to nonlinear coupling is examined.

82-2566

On the Computation of Damped Wind-Excited Vibrations of Overhead Transmission Lines

P. Hagedorn
Inst. f. Mechanik, Technische Hochschule Darmstadt, 6100 Darmstadt, Germany, J. Sound Vib., 83 (2), pp 253-271 (July 22, 1982) 12 figs, 11 refs

Key Words: Transmission lines, Wind-induced excitation, Vortex shedding, Dampers, Fatigue life

In the calculation of wind-excited overhead transmission line vibrations with Stockbridge dampers the damper behavior is usually represented by its impedance corresponding to a vertical translatory damper clamp motion. The moments introduced by the damper clamp into the cable are normally disregarded. In this paper the dampers are characterized by means of a 2 x 2 complex impedance matrix which can be experimentally determined in the laboratory and which includes the effects of the rotatory motion of the clamp. The energy balance method is then adapted to this case and the bending strains in the cable are calculated at the dangerous points.

BARS AND RODS

(Also see No. 2563)

82-2567

Transient Longitudinal Vibrations of a Finite Cylindrical Rod Connected to an Elastic Half-Space

H. Wada
Dept. of Mech. Engrg., Tohoku Univ., Sendai 980, Japan, J. Sound Vib., 82 (3), pp 383-390 (June 8, 1982) 4 figs, 15 refs

Key Words: Rods, Elastic half-space, Longitudinal vibration, Harmonic excitation, Seismic response

An analysis is presented of the transient longitudinal vibrations of a cylindrical rod connected to an elastic half-space under the condition that an arbitrarily shaped free field

vertical acceleration is given as an input. By applying Laplace transformations with respect to time and numerical inverse Laplace transformations, the time histories of the rod acceleration at the interface and at the free end are obtained.

BEAMS

(Also see No. 2610)

82-2568

Flexural Waves and Deflection Mode Shapes of Periodic and Disordered Beams

A.S. Bansal

Dept. of Mech. Engrg., Punjab Agricultural Univ., Ludhiana-141004, India, J. Acoust. Soc. Amer., 72 (2), pp 476-481 (Aug 182) 4 figs, 11 refs

Key Words: Beams, Periodic structures, Flexural vibration, Material frequencies, Mode shapes

This paper deals with free flexural wave motion and natural deflection mode shapes of simply supported infinite uniform periodic beams consisting of repeating units that are identical finite beams having equal and unequal span lengths. Governing equations for the natural frequencies and that for the wave propagation constant have first been setup in terms of the receptances of the individual beam elements. The equations are then applied to compute the natural frequencies and deflection mode shapes together with the propagation constants for some specific disordered periodic beams that include four-span and eight-span periodic and disordered beams. Relationship between the natural frequencies of the symmetric finite repeating beam units and the bounding frequencies of the propagation and attenuation zones has been studied.

82-2569

Transient Response of a Thick Beam of Bimodular Material

C.W. Bert and A.D. Tran

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 551-560 (July/Aug 1982) 7 figs, 2 tables, 15 refs

Key Words: Beams, Bimodular properties, Transient response

Certain materials have different elastic behavior when they are loaded in tension as compared to compression. As an engineering approximation, they are usually modeled as a bimodular material; i.e., a bilinear material having different Young's moduli in tension and in compression. All of the previous analyses of bimodular beams known to the present investigators have been concerned with either static loading or harmonic vibration. Thus, the present work is believed to be the first to consider transient response of such beams. The transfer-matrix method is used to discretize spatially, while the timewise discretization is accomplished by use of the Newmark beta method.

82-2570

Comparison of Analytical and Experimental Results for Free Vibration of Non-Uniform Composite Beams

L.A. Taber and D.C. Viano

Biomedical Sci. Dept., General Motors Res. Labs., Warren, MI 48090, J. Sound Vib., 83 (2), pp 219-228 (July 22, 1982) 9 figs, 2 tables, 17 refs

Key Words: Beams, Cantilever beams, Composite structures, Variable cross section, Resonant frequencies, Mode shapes, Timoshenko theory, Flexural vibration

Resonant frequencies and mode shapes were calculated by a transfer matrix technique for Timoshenko beams of varying cross section. With the non-uniform beam represented by a series of uniform segments, results are given for longitudinal, torsional, and flexural vibration. Comparison with numerical results from the literature confirms the accuracy of the solution for transverse vibration of a homogeneous, tapered cantilever beam.

82-2571

A Comparison of Some Equations for the Flexural Vibration of Damped Sandwich Beams

D.J. Mead

Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 83 (3), pp 363-377 (Aug 8, 1982) 7 figs, 15 refs

Key Words: Beams, Sandwich structures, Damped structures, Flexural vibration

The theories of flexural vibration of damped, three-layer sandwich beams are compared. Depending on the assumptions made about the internal shear stress distribution, the differential equation of transverse flexural displacement is either of fourth or sixth order. The inclusion of the effects of face-plate shear deformation and longitudinal inertia in the analysis yields a sixth order differential equation if the beam section is symmetric, and an eighth order equation if

the section is unsymmetric. Flexural wave speeds and loss factors computed from the theories are presented and compared.

82-2572

Coupled Bending-Bending Vibrations of Pretwisted Tapered Cantilever Beams Treated by the Reissner Method

K.B. Subrahmanyam and J.S. Rao
Dept. of Mech. Engrg., NBKR Inst. of Sci. and Tech., Vidyanagar 524 413, India, J. Sound Vib., 82 (4), pp 577-592 (June 22, 1982) 3 figs, 5 tables, 35 refs

Key Words: Beams, Cantilever beams, Variable cross-section, Natural frequencies, Mode shapes, Flexural vibration, Reissner method

Theoretical natural frequencies and mode shapes of the first four coupled modes of a uniform pretwisted cantilever blade and the first five coupled flexural frequencies of pretwisted tapered blading are determined by using the Reissner method. The shape functions for the bending moments and deflections are developed in series form and with these used in the dynamic Reissner functional, the frequency equation is obtained by minimizing it through the Ritz process. A convergence study made in the case of the pretwisted uniform blade indicates that there appears to be a quicker convergence of the natural frequencies and that a five-term solution yields a set of results that are in good agreement with the theoretical and experimental values of other authors, available in the literature.

82-2573

Vibrations of a Beam Elastically Restrained Against Rotation at One End and Carrying a Guided Mass at the Other

P.L. Vernière de Irassar and P.A.A. Laura
Inst. of Appl. Mech., Puerto Belgrano Naval Base, Argentina, Appl. Acoust., 15 (4), pp 243-249 (July 1982) 5 figs, 1 table, 4 refs

Key Words: Beams, Natural frequencies, Mode shapes

An exact solution to the title problem is obtained using classical beam theory. Natural frequencies and mode shapes are determined as a function of the end flexibility coefficient and of the ratio concerned, end mass/beam mass.

82-2574

Minimum Maximum Deflection and Stress Design of Beams under Harmonic Excitation by Mathematical Programming

S. Adali
Natl. Res. Inst. for Math. Sciences, Pretoria, South Africa, Rept. No. CSIR-TWISK-214, 31 pp (July 1981)
N82-22518

Key Words: Beams, Harmonic excitation, Optimization

The optimal distribution of the cross sectional area of a beam subject to harmonically oscillating loads of the same forcing frequency is computed. The objective function minimized is the maximum dynamic deflection or stress of the beam. The cross sectional area is approximated by splines of order zero or one, and the values of the splines at the knots serve as design variables. The design algorithm consists of successive stages of analysis and optimization. The analysis for a given cross sectional shape is carried out by iteratively solving an equivalent integral equation formulation of the problem. The optimization stage is carried out by using a quasi-Newton minimization routine.

82-2575

Nonlinear Analysis of Beams. Part I: A Survey of Recent Advances

M. Sathyamoorthy
Dept. of Mech. and Industrial Engrg., Clarkson College of Technology, Potsdam, NY 13676, Shock Vib. Dig., 14 (8), pp 19-35 (Aug 1982) 280 refs

Key Words: Beams, Nonlinear theories, Reviews

This survey of literature on nonlinear analyses of beams is limited to papers published since 1972. Geometric, material, and other types of nonlinearities are considered. This paper deals with literature concerning classical nonlinear methods.

82-2576

Destabilizing Effect of Coulomb Friction on Vibration of a Beam Supported at an Axially Oscillating Mount

J. Zajaczkowski
Lodz Technical Univ., Lodz, Poland, J. Sound Vib., 79 (4), pp 575-580 (Dec 22, 1981) 5 figs, 4 refs

Key Words: Beams, Coulomb friction, Parametric excitation

This paper is concerned with parametric vibration of a beam having one end supported at a motionless mount and the other at an axially oscillating mount. It is shown that the time-history of the motion of the beam may be expressed in terms of Jacobi elliptic functions. The effect of the friction force, resulting from the relative motion of the mount and the beam, on the vibration is studied. The instability regions are found and plotted.

CYLINDERS

(See No. 2602)

FRAMES AND ARCHES

82-2577

Separation of Element Spaces by Contraction and an Application to Determination of Bounds to Natural Frequencies of Frames

E. Dokumaci
Faculty of Mech. Engrg., Ege Univ., Izmir, Turkey,
J. Sound Vib., 82 (3), pp 445-457 (June 8, 1982) 3 tables, 5 refs

Key Words: Frames, Natural frequencies, Boundary value problems

This paper presents the application of a new method to the determination of lower bounds to natural frequencies of continuous systems which admit the formulation of elastically orthogonally refined finite elements that yield upper bounds to the natural frequencies. This method can also be seen as a direct method of separation of element spaces. The utility of the process is shown with reference to vibration problems of frames.

82-2578

Nonlinear Dynamic Analysis of Framed Structures Using a Finite Element Method

D.W. Keck
Ph.D. Thesis, Georgia Inst. of Tech., 374 pp (1982) DA8215263

Key Words: Framed structures, Finite element technique, Nonlinear theories, Computer programs

A general methodology and an associated computer system are developed for the static and dynamic nonlinear analysis of framed structures. The nonlinearity includes both finite deformation effects and elasto-plasticity. Lagrangian displacement based beam-column finite elements are developed. A consistent nonlinear frame theory is developed based on Lagrangian mechanics. The result of this development is a variety of kinematic models which incorporate different levels of geometric nonlinearity. The models are used as the basis for a family of planar and spatial beam-column finite elements.

MEMBRANES, FILMS, AND WEBS

(See No. 2580)

PLATES

(Also see Nos. 2593, 2610, 2678)

82-2579

Large Amplitude Flexural Vibration of Layered Composite Plates with Cutouts

J.N. Reddy
Dept. of Engrg. Sci. and Mech., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061,
J. Sound Vib., 83 (1), pp 1-10 (July 8, 1982) 5 figs, 3 tables, 11 refs

Key Words: Plates, Composite structures, Layered materials, Flexural vibration, Large amplitudes

The large amplitude flexural vibration of rectangular plates is investigated. A finite element based on a Reissner-Mindlin type of shear deformable theory governing laminated anisotropic composite plates, and the nonlinear (large rotations) strain-displacement relations of the von Karman theory are employed. Numerical results are presented for rectangular plates with rectangular cutouts. The parametric effects of side to thickness ratio (shear deformation), aspect ratio, plate side to cutout side ratio, anisotropy, and lamination on linear and nonlinear frequencies are investigated.

82-2580

Vibrations of Cross-Shaped, I-Shaped, and L-Shaped Membranes and Plates

T. Irie, G. Yamada, and K. Ashida
Dept. of Mech. Engrg., Faculty of Engrg., Hokkaido

Univ., Sapporo, 060, Japan, J. Acoust. Soc. Amer., 72 (2), pp 460-465 (Aug 1982) 7 figs, 3 tables, 14 refs

Key Words: Membranes (structural members), Plates, Natural frequencies, Mode shapes

The natural frequencies (eigenvalues of vibration) and mode shapes are presented for cross-shaped, I-shaped, and L-shaped membranes and simply supported plates. An irregularly shaped membrane is formed on a rectangular base membrane by fixing several segments. The reaction forces acting on the edges of an actual membrane are expanded into Fourier series with unknown coefficients, and homogeneous equations for the coefficients are derived by the restraint conditions on the edges. The natural frequencies and mode shapes of the actual membrane are determined by calculating the eigenvalues and eigenvectors of the equations. The numerical values obtained for membranes can be immediately converted into those of simply supported plates by the dynamical analogy between membrane and plate.

82-2581

On the "Overlapping Resonances" Concept of Acoustic Transmission through an Elastic Plate, I: An Examination of Properties

A. Freedman

65 Mount Pleasant Ave., Weymouth, Dorset DT3 5JF, UK, J. Sound Vib., 82 (2), pp 181-195 (May 22, 1982) 5 figs, 1 table, 28 refs

Key Words: Plates, Elastic properties, Submerged structures, Acoustic transmission

The Fiorito, Madigosky and Uberall approximate representation of the acoustic transmission coefficient of an infinite, isotropic, elastic plate by resonances associated with Lamb modes is examined and clarification of its properties is obtained. Some theoretical extension is provided which validates coherent addition of these overlapping resonances. Minor limitations shown are that the theory is inapplicable near grazing incidence and that it gives only a partial solution at incidence beyond the second critical angle when the frequency thickness product is the variable.

82-2582

On the "Overlapping Resonances" Concept of Acoustic Transmission through an Elastic Plate, II: Numerical Examples and Physical Implications

A. Freedman

65 Mount Pleasant Ave., Weymouth, Dorset DT3 5JF, UK, J. Sound Vib., 82 (2), pp 197-213 (May 22, 1982) 14 figs, 14 refs

Key Words: Plates, Elastic properties, Submerged structures, Acoustic transmission

In a companion paper the Fiorito, Madigosky and Uberall approximate theory of transmittivity of an infinite, isotropic, elastic plate in terms of Lamb mode resonances is examined, and extended by validating coherent addition of these overlapping resonances. This paper provides numerical and heuristic tests which yield convincing proof of the applicability of the overlapping resonances concept. At various thicknesses of a water-immersed, steel plate, including the half-space and zero thickness limits, the behavior is shown to be compatible with known exact behavior. Overlapping resonances explain the reduction towards zero of the transmittivity near the coincidence angles of the zero order Lamb modes as these converge to the Rayleigh angle.

82-2583

Axisymmetric Vibrations of Polar Orthotropic Annular Plates of Variable Thickness

R. Lal and U.S. Gupta

Dept. of Math., Univ. of Roorkee, Roorkee 247672, India, J. Sound Vib., 83 (2), pp 229-240 (July 22, 1982) 5 figs, 4 tables, 14 refs

Key Words: Plates, Annular plates, Variable cross section, Axisymmetric vibration, Natural frequencies, Mode shapes

In this study of the free axisymmetric vibrations of polar orthotropic annular plates of linearly varying thickness, on the basis of the classical theory of plates, the Chebyshev collocation technique has been employed to solve the differential equation governing the transverse motion of such plates. Frequencies, mode shapes and moments have been computed for three different boundary conditions for various values of the rigidity ratios, the radii ratio and the taper parameter for the first two modes of vibration.

82-2584

Air Elastic Vibrations of a Metal Plate Supported on Air Cushions (Vibrations Aero-Elastiques d'une Tole sur Coussins d'Air)

J.P. Allioud

Association Aeronautique et Astronautique de France, Paris, France, Rept. No. AAAF-NT-81-08,

40 pp (Nov 1981) (Pres. at Colloque d'Aerodynamique Appliquee (18th), Poitiers, Nov 18-20, 1981)
PB82-204280
(In French)

Key Words: Plates, Vibration isolation

Painted metal plates supported on air cushions improve the efficiency of industrial installations, because the process is not limited by the weak level of the chain furnaces and the constraints of traction in the metal sheet. Tests have shown considerable transversal air elastic instabilities; these phenomena studied through experiments are, therefore, the subject of a theory using the Galerkin formulation as a means of bidimensional model.

82-2585

Vibration and Stability of Stiffened Annular Plates

T. Irie, G. Yamada, and S. Aomura

Dept. of Mech. Engrg., Faculty of Engrg., Hokkaido Univ., Sapporo, 060 Japan, J. Acoust. Soc. Amer., 72 (2), pp 466-471 (Aug 1982) 4 figs, 2 tables, 12 refs

Key Words: Plates, Annular plates, Stiffened plates, Stiffener effects, Natural frequencies, Mode shapes, Dynamic buckling

The vibration and stability of radially stiffened annular plates subjected to an in-plane force uniformly distributed at the edges are analyzed by the energy method. For this purpose, the transverse deflection of a stiffened annular plate is written in a series of the products of the deflection function of a sectorial beam with a small angle and the trigonometric function of angular coordinate. The deflection function of the sectorial beam is approximately expressed by a quintic spline function satisfying the boundary conditions at the edges, and the frequency equation of the plate is derived by the Ritz method. The method is applied to annular plates with several stiffeners of uniform rectangular cross section located at equal angular intervals; the natural frequencies and the critical buckling loads are calculated numerically and the effects of stiffeners on them are studied.

82-2586

Nonlinear Flexural Vibration of Moderately Thick-Orthotropic Circular Plates

M. Sathyamoorthy and C.Y. Chia

Dept. of Civil Engrg., The Univ. of Calgary, Calgary, Alberta, T2N 1N4, Canada, Ing. Arch., 52 (3/4), pp 237-243 (1982) 5 figs, 2 tables, 12 refs

Key Words: Plates, Circular plates, Orthotropism, Transverse shear deformation effects, Rotatory inertia effects, Flexural vibration

A nonlinear vibration theory which includes the effects of transverse shear deformation and rotatory inertia is formulated for rectilinearly orthotropic circular plates using Berger's method. A solution to the governing equations for rigidly clamped plates is obtained on the basis of a single-mode approach by use of Galerkin's method and numerical Runge-Kutta procedure. A good agreement is found between present results and those obtained by a more accurate theory for nonlinear static and dynamic cases.

82-2587

Sound Power and Radiation Efficiency of a Circular Plate

S. Czarnecki, Z. Engel, and R. Panuszka

Dept. of Aeroacoustics, Inst. of Fundamental Technological Res., Polish Academy of Sciences, 00-049 Warsaw, Poland, Arch. Acoust., 6 (4), pp 339-358 (1981) 10 figs, 2 tables, 14 refs

Key Words: Plates, Circular plates, Vibrating structures, Sound waves, Wave propagation

The problem of estimating the sound radiation by vibrating surfaces in the case of a circular plate clamped on the circumference is considered. The aim of this paper is to verify the values of the equivalent surfaces of the plate, which were obtained theoretically, with the experimental values obtained in the free field and reverberant field conditions.

82-2588

Vibration of a Rigid Disc on a Transversely Isotropic Elastic Half Space

D.J. Kirkner

Dept. of Civil Engrg., Univ. of Notre Dame, Notre Dame, IN 46556, Intl. J. Numer. Anal. Methods Geomech., 6 (3), pp 293-306 (July-Sept 1982) 7 figs, 24 refs

Key Words: Disks (shapes), Harmonic response, Vibrating structures

The problem of a massless, rigid disc vibrating harmonically on a constrained transversely isotropic elastic half space is considered. The material is called constrained because it is assumed that the elastic constants satisfy a certain equation.

The problem for each mode of vibration is reduced to the solution of a Fredholm integral equation of the second kind. Results are presented to show the general effect of the material anisotropy.

82-2589

An Analytical Solution for the Free Vibration Analysis of Rectangular Plates Resting on Symmetrically Distributed Point Supports

D.J. Gorman

Dept. of Mech. Engrg., Univ. of Ottawa, Ottawa, Ontario, Canada K1N 6N5, J. Sound Vib., 79 (4), pp 561-574 (Dec 22, 1981) 8 figs, 4 tables, 8 refs

Key Words: Plates, Rectangular plates, Free vibration, Vibration analysis

A general analytical solution is obtained for the free vibration of rectangular plates supported on their lateral surface by symmetrically distributed point supports. Highly accurate eigenvalues are provided for a square plate supported at various points along the diagonal. Results are compared with earlier findings obtained by a finite element method. It is shown that the method may be extended to solve various other problems. The tabulation of eigenvalues appears to be the most comprehensive yet made for a square plate with point supports on the diagonals.

82-2590

Large Amplitude Vibrations of a Clamped Orthotropic Square Plate Carrying a Concentrated Mass

B. Banerjee

Dept. of Math., Jalpaiguri Government Engrg. College, Jalpaiguri, West Bengal, India, J. Sound Vib., 82 (3), pp 329-333 (June 8, 1982) 1 fig, 10 refs

Key Words: Plates, Rectangular plates, Mass-plate systems, Vibration analysis, Large amplitudes

The nonlinear vibration of a clamped orthotropic square plate carrying a concentrated mass has been investigated. Von Kármán's equations expressed in terms of displacement components have been used. Numerical results, shown in the form of graphs, are discussed.

82-2591

Frequency and Loss Factor of Rectangular Plates Reinforced by Intermediate Viscoelastic Line Supports

H. Saito and H. Yamaguchi

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 83 (2), pp 157-162 (July 22, 1982) 5 figs, 4 refs

Key Words: Plates, Rectangular plates, Stiffened plates, Viscoelastic damping

Free vibrations of rectangular plates supported with intermediate viscoelastic line supports which are placed in a row parallel to one of the edges of the plate are discussed. In the analysis, the intermediate viscoelastic line supports are considered as massless line springs. On the assumption that the edges of the plate normal to the line supports are simply supported, the frequency equation is derived using a transfer matrix method. The effects of the number and the stiffness of the viscoelastic line supports on the damped natural frequency and logarithmic decrement of the system are investigated.

SHELLS

(Also see Nos. 2511, 2610)

82-2592

Dynamic Response of an Orthotropic Cylindrical Shell to Rapid Heating

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Dept. of Mech. Engrg., Univ. of Osaka Prefecture, Mozu-Umemachi, Sakai, Osaka 591, Japan, J. Sound Vib., 83 (1), pp 27-35 (July 8, 1982) 6 figs, 9 refs

Key Words: Shells, Cylindrical shells, Temperature effects

The dynamic response of the thermal displacements and stresses in a homogeneous, orthotropic cylindrical shell subjected to rapid heating are studied. Equations containing both thermal and inertia terms are developed and the solutions are obtained using Fourier and Laplace transform methods, after finding the temperature distribution by solving the non-stationary equation of heat conduction. Numerical examples are presented to examine the effects of thermal and mechanical orthotropic properties.

82-2593

On the Vibration of Shells with Timoshenko-Mindlin Type Shear Deflections and Rotatory Inertia

W. Soedel

School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 83 (1), pp 67-79 (July 8, 1982) 21 refs

Key Words: Shells, Cylindrical shells, Vibration analysis, Plates, Timoshenko theory, Mindlin theory, Transverse shear deformation effects, Rotatory inertia effects

Equations of motion of shells are formulated in curvilinear co-ordinates that are consistent with assumptions made in the Timoshenko beam and also the Mindlin plate equation. This consistency is proven by obtaining the Timoshenko and Mindlin equations from the derived shell equations by geometrical reduction. The implication of the Timoshenko type shear is illustrated by contrasting the free vibration behavior of the special case of a cylindrical shell with the behavior of the Timoshenko beam and the Mindlin plate.

82-2594

Buckling and Vibration of Cross-Ply Laminated Non-Circular Cylindrical Shells

K.P. Soldatos and G.J. Tzivanidis

Dept. of Mech., Univ. of Ioannina, Greece, J. Sound Vib., 82 (3), pp 425-434 (June 8, 1982) 3 figs, 4 tables, 18 refs

Key Words: Free vibration, Shells, Cylindrical shells

The free vibration problem of a thin composite cross-ply laminated non-circular cylindrical shell subjected to an axial compression is studied. The equations of motion are derived, in the framework of the Donnell-type theory, in terms of the shell middle surface displacement components. The differential equations of motion have variable coefficients and are solved by employing Galerkin's method. As an application, the problem of the free vibrations and buckling of cross-ply laminated oval cylinders is studied. Numerical results for antisymmetric and unsymmetric cross-ply laminated shellls of graphite-epoxy are presented and discussed.

82-2595

On the Dynamic Response of Fluid Coupled Coaxial Cylinders

S.J. Brown

Ph.D. Thesis, Univ. of Akron, 342 pp (1982) DA8215186

Key Words: Shells, Circular shells, Concentric structures, Submerged structures

The Navier-Stokes equations are used to derive inertia and damping forces as a function of the oscillating circular coaxial shell mode shapes which bound viscous fluid within a finite length annular region. Simple expression axial mode coefficients are derived that may be used with the virtual mass and damping approach. A comprehensive survey of the significant experimental, theoretical, and numerical investigations into this area is presented. Technical milestones are discussed and pertinent theoretical formulae are briefly outlined.

82-2596

Natural Frequencies of an Elastic Spherical Shell Submerged in a Compressible Viscous Fluid Medium

T.C. Su

Dept. of Civil Engrg., Texas A&M Univ., College Station, TX 77843, J. Sound Vib., 83 (2), pp 163-169 (July 22, 1982) 3 figs, 4 refs

Key Words: Shells, Spherical shells, Submerged structures, Viscous damping, Sound waves

The frequency equations previously derived for free, axisymmetric vibrations of an elastic spherical shell submerged in a compressible viscous fluid are reduced to a simple polynomial expression. Its complete solutions are numerically obtained and presented for a steel shell submerged in water.

82-2597

Dynamic Instability of Truncated Conical Shells, with Variable Modulus of Elasticity, under Periodic Compressive Forces

C. Massalas, A. Dalamangas, and G. Tzivanidis

Dept. of Mech., Univ. of Ioannina, Ioannina, Greece, J. Sound Vib., 79 (4), pp 519-528 (Dec 22, 1981) 6 figs, 1 table, 6 refs

Key Words: Shells, Conical shells, Variable material properties, Modulus of elasticity, Periodic excitation, Vibration analysis

The dynamic instability of truncated conical shells with variable modulus of elasticity, subjected to periodic axial compressive forces, is studied. The formulation of the problem is based on the dynamic version of Donnell type basic equations with bending deformations neglected before instability. By applying Galerkin's method, the basic equations are reduced to a system of coupled Mathieu-Hill equations, from which the principal instability regions are determined by using Bolotin's method. The free vibration problem, as well as the classical buckling problem of the shell considered, are also discussed.

PIPES AND TUBES

82-2598

Pipe Whip Dynamics: An Experimental and Analytical Investigation

D. Peterson

Ph.D. Thesis, Univ. of Akron, 192 pp (1982)
DA8216612

Key Words: Pipes (tubes), Whipping phenomena, Nuclear power plants, Computer programs, Finite element techniques

Several experiments and analyses are performed in support of finite element analysis modeling of postulated pipe whip in nuclear power plants. A number of static and higher strain-rate tensile tests are conducted in this study to characterize the material properties of SA-106 carbon steel pipes. Results of finite element analyses are compared with the displacements and strains measured during static inelastic bending experiments. Analytical and experimental studies of the dynamic response of a system with material and geometric nonlinearity are described.

82-2599

The Radiation of High Frequency Sound Out of a Jet Pipe

A.M. Cargill

Noise Dept., Rolls-Royce Ltd., Derby DE2 8BJ, UK, J. Sound Vib., 83 (3), pp 313-337 (Aug 8, 1982) 11 figs, 32 refs

Key Words: Ducts, Pipes (tubes), Sound waves, Wave propagation

A simple model problem is discussed: the radiation of sound out of a semi-infinite cylindrical pipe, with internal and external flows. Two approximate high frequency solutions are presented, one based on Kirchhoff's approximation and the other in the spirit of the geometrical theory of diffraction, and are compared with Munt's exact solution by the Wiener-Hopf technique. The radiation from a jet emerging from an orifice in a baffle plate is also discussed. The differences between this simple model and an aero engine configuration are considered, showing how the results are modified by the presence of a secondary flow (e.g., the fan stream on a turbofan engine), by the contraction of the final nozzle, and by the presence of many duct modes in the pipe.

82-2600

Low Frequency Acoustic Radiation from a Jet Pipe – A Second Order Theory

A.M. Cargill

Noise Dept., Rolls-Royce Ltd., Derby DE2 8BJ, UK, J. Sound Vib., 83 (3), pp 339-354 (Aug 8, 1982) 5 figs, 26 refs

Key Words: Pipes (tubes), Ducts, Aircraft noise, Jet noise, Engine noise, Sound waves, Wave propagation

In several recent papers, Munt has solved the problem of the radiation of sound out of a jet pipe by the Wiener-Hopf technique. In this extension of his work explicit formulae are given for both the far field radiation and the sound reflected back up the pipe for an incident plane wave. These formulae, which are valid to second order in the ratio of duct diameter to wavelength, are shown to be in excellent agreement with Munt's exact numerical computations.

82-2601

Thermal Acoustic Oscillation in Annular Flow of Low Temperature Helium

J.A. Liburdy

Clemson Univ., Clemson, SC, ASME Paper No. 82-HT-12

Key Words: Pipes (tubes), Fluid-induced excitation

Cryogenic flow lines have traditionally been plagued with the existence of thermally driven acoustic oscillations when the fluid experiences a downstream thermal energy input. This energy gain is manifested in a net rise in the upstream energy content of the cryogen. The transport process is one of low frequency pressure and density waves characterized by the tube geometry, fluid properties and boundary conditions. This phenomenon has been studied for the cases of circular tube flow and annular flow conditions.

82-2602

Low Frequency Two Dimensional Flows through a Sparse Array of Bodies

T.F. Balsa

General Electric Corporate Res. and Dev., Schenectady, NY, J. Sound Vib., 82 (4), pp 489-504 (June 22, 1982) 4 figs, 10 refs

Key Words: Cylinders, Tube arrays, Fluid-induced excitation, Low frequencies

A low frequency and weak interaction theory is developed to study certain types of unsteady two-dimensional flows through an array of bodies. The results, together with the Taylor transformation, provide a simple and systematic yet powerful technique for obtaining solutions for an important, but otherwise extremely difficult, class of problems. The general results are applied to two specific examples in order to illustrate the approach and to produce some interesting results.

82-2603

Guided Waves in a Circular Duct Containing an Assembly of Circular Cylinders

W.H. Lin
Components Tech. Div., Argonne Natl. Lab., Argonne, IL 60439, J. Sound Vib., 79 (4), pp 463-477 (Dec. 22, 1981) 7 figs, 4 tables, 28 refs

Key Words: Ducts, Cylinders, Tube arrays, Sound waves, Wave propagation, Nuclear reactors, Acoustic excitation

This paper provides an analytical scheme to calculate the admissible acoustic propagation modes of fluid in a circular duct containing an assembly of circular cylinders, as might occur in gas-cooled fast breeder reactors and advanced gas-cooled reactors. The duct wall and cylinders are assumed to be stationary, and their axes are assumed to be parallel to each other. The solution to the acoustic wave equation is expressed in a sum of the partial fluid velocity potentials associated with each rod co-ordinate and duct co-ordinate. The technique of transformation of cylindrical wave functions is then used to solve the boundary value problem. Two kinds of acoustic boundary conditions are considered, acoustically hard and acoustically soft, respectively.

DUCTS

(Also see Nos. 2599, 2600, 2603, 2635, 2657)

82-2604

Oscillations of an Impinging Turbulent Jet: Coherence Characterization via Conditional Sampling

D. Rockwell and H. Karadogan
Dept. of Mech. Engrg. and Mech., Lehigh Univ., Bethlehem, PA 18015, J. Sound Vib., 83 (1), pp 111-124 (July 8, 1982) 8 figs, 11 refs

Key Words: Ducts, Fluid-induced excitation, Statistical analysis

By using zero crossing statistics, in conjunction with recursive digital filtering, to determine self- and cross-probability densities of velocity and pressure, the degree of phase fluctuation of organized oscillations of turbulent jet flow through a cavity is characterized as a function of mean phase deviation from the lock-on condition; lock-on, producing maximum pressure amplitude, corresponds to a time-averaged phase difference between organized velocities at the exit and entrance of the cavity of $2n\pi$. As a frequency jump is approached, there is mean phase deviation from this $2n\pi$ condition, and the degree of phase (or period) fluctuation increases; at the jump, cross-probability densities show no discernible coherence. Concerning the evolution of the jet in the streamwise direction, growth of the time-averaged organized wave amplitude, obtained by using a wave-eduction method, is shown to be associated with a decrease in phase fluctuation of the velocity. However, self-probabilities of pressure, and cross-probabilities between pressure and exit velocity, are essentially invariant between cavity exit and inlet, reflecting dominance of the acoustic contribution to the unsteady pressure field at separation.

82-2605

Conversion of Acoustic Energy by Lossless Liners

W. Möhring and W. Eversman
Max-Planck-Institut f. Stromungsforschung, D-3400 Göttingen, Germany, J. Sound Vib., 82 (3), pp 371-381 (June 8, 1982) 3 figs, 16 refs

Key Words: Ducts, Acoustic linings, Mechanical admittance

The Blokhintzev acoustic energy equation is applied to a two-dimensional duct containing a uniform flow with a finite length lining. It is shown that the difference of the incident and outgoing acoustic energy differs in general from the energy dissipated in the liner, the difference being related to the displacements at the liner's edges. It is shown that in the case of a locally reacting lossless liner for frequencies below the first cut-off frequency and for low Mach number acoustic energy is generated if the flow and the incident sound wave are in the same direction and is absorbed if these two directions are opposite unless special edge conditions are met. It is also shown under the same conditions that the ratio of the reflection coefficient at finite flow velocity to the reflection coefficient at vanishing velocity is to first order in Mach number independent of the liner characteristics. A numerical calculation confirms these predictions at least for mass-like liner admittance.

82-2606

Noise Generated by Flow over Perforated Surfaces

P.A. Nelson

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 83 (1), pp 11-26 (July 8, 1982) 11 figs, 22 refs

Key Words: Ducts, Acoustic linings, Hole-containing media, Fluid-induced excitation, Noise generation

This work deals with the prediction of the noise generated by unsteady flow over the surface of acoustically absorbent duct linings. Ffowcs Williams' analysis of the acoustics of turbulence near sound absorbent linings is used as a theoretical basis. An equivalent source model is used to describe the radiated sound in terms of the mass flow driven through the circular perforations of a liner surface by hydrodynamic pressure fluctuations.

82-2607

Verification of a One-Dimensional Analysis of Sound Propagation in a Variable Area Duct without Flow

J.H. Miles

NASA Lewis Res. Ctr., Cleveland, OH 44118, J. Acoust. Soc. Amer., 72 (2), pp 621-624 (Aug 1982) 3 figs, 11 refs

Key Words: Ducts, Variable cross section, Sound propagation

A predicted standing wave pressure and phase angle profile for a hard wall rectangular duct with a region of converging-diverging area variation is compared to published experimental measurements in a study of sound propagation without flow. The factor of 1/2 area variation used is of sufficient magnitude to produce large reflections. The prediction is based on a transmission matrix approach developed for the analysis of sound propagation in a variable area duct with and without flow. The agreement between the measured and predicted results is shown to be excellent.

82-2608

Determination of Two-Stroke Engine Exhaust Noise by the Method of Characteristics

A.D. Jones and G.L. Brown

Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia, Australia, J. Sound Vib., 82 (3), pp 305-327 (June 8, 1982) 14 figs, 23 refs

Key Words: Ducts, Exhaust systems, Reciprocating engines, Noise generation, Method of characteristics

A computational technique was developed for the method of characteristics solution of a one-dimensional compressible, unsteady flow in a duct as applied to the wave action in an engine exhaust system. By using the method it was possible to compute the detailed flow in both straight pipe and tuned expansion chamber exhaust systems as matched to the flow from the cylinder of a small two-stroke engine. The radiated exhaust noise was then determined by assuming monopole radiation from the tailpipe outlet. Very good agreement with experiment on an operating engine has been achieved in the calculation of both the third-octave radiated noise and the associated pressure cycles at several locations in the different exhaust systems.

82-2609

A Study of Resonant-Cavity and Fiberglass-Filled Parallel Baffles as Duct Silencers

P.T. Soderman

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. NASA-A-8363, NASA-TP-1970, USAAVRADCOM-TR-81-A-2, 67 pp (Apr 1982)
AD-A114 328

Key Words: Baffles, Noise reduction, Ducts

Acoustical performance and pressure drop were measured for two types of splitters designed to attenuate sound propagating in ducts-resonant-cavity baffles and fiberglass-filled baffles. Arrays of four baffles were evaluated in a wind tunnel at flow speeds from 0 to 41 m/sec. Emphasis was on measurements of silencer insertion loss as affected by variations of such parameters as baffle length, baffle thickness, perforated skin geometry, cavity size and shape, cavity damping, wind speed, and acoustic field directivity. An analytical method for predicting silencer performance is described and compared with measurements.

BUILDING COMPONENTS

(Also see No. 2676)

82-2610

Mechanics of Bimodular Composite Structures

C.W. Bert and J.N. Reddy

Univ. of Oklahoma, Norman, OK 73019, Rept. No. OU-AMNE-82-4, 15 pp (July 1982)

Key Words: Composite structures, Fiber composites, Beams, Plates, Shells, Transverse shear deformation effects, Rotatory inertia effects

This report is a survey of the mechanics of beam and plate structures laminated of fiber-reinforced composite materials having different elastic and thermoelastic properties in tension and compression. Examples of such materials include tire cord-rubber, wire-reinforced solid propellants, and soft biological materials. Specific topics covered include: mathematical models of fiber-reinforced bimodular materials and their experimental verification; static and dynamic analysis of laminated and sandwich beams; plane elasticity; analysis of deflection and free and transient vibration of laminated plates and shells. In all of these analyses, thickness-shear deformation and rotatory inertia are included. The solution methods used include closed-form, transfer-matrix, and finite-element techniques.

82-2611

Influence of Specimen Frame on Sound Transmission Loss Measurement

A.C.C. Warnock

Div. of Bldg. Res., Natl. Res. Council of Canada, Ottawa, Canada, Appl. Acoust., 15 (4), pp 307-314 (July 1982) 5 figs, 4 refs

Key Words: Sound transmission loss, Measurement techniques, Walls

Increased sound transmission through several wall specimens as a result of interaction with the specimen mounting frame is described. The effect of the frame is reduced by shielding it from the sound fields.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2519, 2520, 2521, 2651, 2676, 2683, 2684)

82-2612

Application of the Short-Term L_{eq} to the Identification and Quantification of Several Sources Constituting an Environment

P. Luquet

Dept. of Environmental Acoustics, Laboratoire National D'Essais, Paris, France, Appl. Acoust., 15 (5), pp 377-388 (Sept 1982) 8 figs, 4 tables, 3 refs

Key Words: Noise source identification

A technique applicable to situations with different noise sources is developed on the basis of a series of limited data (short-term L_{eq}). This technique makes acoustic monitoring of a site possible, identifying and evaluating the respective contributions of the different components of the environment studied.

82-2613

A Recursive Method for the Determination of the Output Power Spectrum of Some Nonlinear Systems

A. Gabor and J. Zarzycki

Inst. of Telecommunication and Acoustics, Technical Univ. of Wroclaw, 50-317 Wroclaw, Poland, Arch. Acoust., 6 (4), pp 329-338 (1981) 1 fig, 8 refs

Key Words: Power spectral density, Noise source identification

This paper presents a new method for the determination of the output power spectral density of different types of cascading a linear system with memory and a nonlinear system without memory, with a stationary Gaussian input. This method permits uniform determination of the output spectrum for each type of the systems mentioned above. The recursive form of the resulting expressions also permits fast calculation of the output spectral density for higher orders of nonlinearity.

82-2614

Sound Propagation over Ground: Analytical Approximations and Experimental Results

D. Habault

Laboratoire de Mécanique et d'Acoustique, Centre National de la Recherche Scientifique, 13277 Marseille Cedex 9, France, J. Sound Vib., 79 (4), pp 551-560 (Dec 22, 1981) 4 figs, 14 refs

Key Words: Sound waves, Point source excitation, Wave propagation, Numerical analysis, Experimental test data

Approximations of the sound field emitted by a point source in the presence of the ground have recently been developed. These analytical expressions, slightly improved for computation, are compared with an exact representation of the

sound pressure and two kinds of experimental results. The approximations, easy to compute, provide a reasonable accuracy for predictions of the sound levels in the asymptotic and intermediate (preceding the asymptotic) regions. Numerical techniques (an optimization method) are presented for obtaining the best value of the *ground normal impedance*, from data obtained in Kundt's tube and far field measurements.

82-2615
Detection of Rotating Machinery from Acoustic and Vibrational Energy
J.P. Reilly and R.J. Taylor
Appl. Physics Lab., Johns-Hopkins Univ., Laurel, MD, Rept. No. JHU/APL/CPE-8108, 54 pp (Nov 1981)
PB82-179979

Key Words: Rotating machinery, Noise generation, Acoustic detection, Noise reduction

This study analyzes detection ranges for a 30 kW diesel-electric generator placed in a forested area having good propagation characteristics and low ambient noise levels. Detection from both acoustic and vibrational energy is analyzed. Detector models are based on human aural detection, and also on automatic detection by a signal processing unit. Quieting necessary to limit the detection range to 500 m is determined.

82-2616
Impedance-Matching Properties of an Inhomogeneous Matching Layer with Continuously Changing Acoustic Impedance
P.C. Pedersen, O. Tretiak, and P. He
Biomedical Engrg. and Science Inst., Drexel Univ., Philadelphia, PA 19104, J. Acoust. Soc. Amer., 72 (2), pp 327-336 (Aug 1982) 6 figs, 9 refs

Key Words: Impedance-matching technique, Acoustic impedance, Transducers

This paper analyzes the impedance-matching properties of an inhomogeneous layer whose specific acoustic impedance varies smoothly across the layer, from the effective value of the transducer specific acoustic impedance to the value of the output medium specific acoustic impedance. The energy reflection and transmission coefficients for an inhomogeneous layer with no attenuation and constant propagation speed are derived, and the results are presented for selected profiles. The performance of an inhomogeneous matching layer with an exponential impedance profile is compared with a quarter-wavelength matching plate. The general case in which both sound speed and density of the inhomogeneous matching layer may vary is analyzed; the specific acoustic *impedance profile as a function of travel time* is found to be a principal factor, determining the transmission and reflection properties. The spatial functions of the acoustic parameters are determined for the case where both density and sound speed vary exponentially with travel time.

82-2617
Understanding Noise Control: Part 1. Principles and Methods for Reducing Inplant Noise
R. Moulder
Acoustical Res., Owens-Corning Fiberglas Corp., Granville, OH, Plant Engrg., 36 (17), pp 75-77 (Aug 19, 1982) 5 figs

Key Words: Industrial facilities, Noise generation, Noise measurement, Noise reduction

This article is the first of two describing how industrial noise can be controlled. It discusses acoustical principles, sound measuring techniques, and methods for reducing noise levels inside a plant.

82-2618
Sound Propagation above an Impedance Boundary
T. Kawai, T. Hidaka, and T. Nakajima
Takenaka Tech. Res. Lab., Tokyo 136, Japan, J. Sound Vib., 83 (1), pp 125-138 (July 8, 1982) 4 figs, 3 tables, 25 refs

Key Words: Sound waves, Wave propagation, Point source excitation

An asymptotic solution of the scalar wave field due to a point source above a locally reacting plane surface is obtained by a modified saddle point method. Numerical calculation indicates that the relatively simple solution is more accurate than the Thomasson asymptotic solution and the Chien-Soroka solution.

82-2619
An Approximation to the Three-Dimensional Parabolic-Equation Method for Acoustic Propagation
J.S. Perkins and R.N. Baer

Large Aperture Acoustics Branch, Naval Res. Lab., Washington, DC 20375, J. Acoust. Soc. Amer., 72 (2), pp 515-522 (Aug 1982) 14 figs, 22 refs

Key Words: Sound waves, Wave propagation

Reported previously was an algorithm, based on the parabolic approximation to the reduced wave equation, for the propagation of sound in three dimensions in the ocean. Presented here is a simpler algorithm: solve N two-dimensional problems and combine the results to form an approximate three-dimensional solution. Analytic and numerical results show that this N x 2D approach is an excellent approximation to the original algorithm for realistic ocean environments, even those where fronts and eddies are present, provided redirection of energy in azimuth due to boundary interaction is not important. The two computer models are compared based on these algorithms for several test cases by considering how they distribute energy spatially, and by simulating the performance of a hypothetical horizontal array of hydrophones placed in the calculated complex-valued acoustic fields.

82-2620

Ground Effect Analysis: Surface Wave and Layer Potential Representations

D. Habault and P.J.T. Filippi
Laboratoire de Mécanique et d'Acoustique, Centre National de la Recherche Scientifique, 13277 Marseille Cedex 9, France, J. Sound Vib., 79 (4), pp 529-550 (Dec 22, 1981) 2 figs, 27 refs

Key Words: Sound reflection, Sound waves, Numerical analysis

This paper presents two kinds of analytical exact expressions of the sound field reflected by a plane boundary, as obtained by using either surface wave or layer potentials representations. Both solutions are first expressed as a sum of integrals which have a form suitable for numerical computation. These integrals are then expanded into convergent series which provide analytical approximations of the solution. Numerical techniques are proposed for computing the surface wave representation and the approximation deduced from the layer potentials representation. This approximation and the classical one (sum of the surface wave and the first two terms of the asymptotic series) are compared with the exact solution. Several examples show that the approximate formulas established here are valid on a range much wider than the validity domain of the classical ones.

82-2621

Linearized Supersonic Motion under a Lorentz-Like Transformation

T.S. Shankara and S.N. Majhi
Dept. of Math., Indian Inst. of Tech., Madras-600036, India, J. Sound Vib., 82 (3), pp 391-400 (June 8, 1982) 5 figs, 10 refs

Key Words: Sound waves, Wave propagation

The symmetry of the Lorentz transformation is shown to be inherent in the acoustics of sources in subsonic motion. The symmetry in the supersonic case is expressed in terms of a Lorentz-like transformation. The linearized wave equation describing the motion of a point source and a thin airfoil in supersonic motion is discussed by using this new transformation. Results in the paper suggest that there is a unified relativistic foundation for the acoustics of both subsonic and supersonic sources.

82-2622

Coupled Amplitude Theory of Nonlinear Surface Acoustic Waves

N. Kalyanasundaram, R. Ravindran, and P. Prasad
Dept. of Applied Math., Indian Inst. of Science, Bangalore – 560, 012, India, J. Acoust. Soc. Amer., 72 (2), pp 488-493 (Aug 1982) 3 figs, 5 refs

Key Words: Sound waves, Wave propagation, Boundary value problems

The nonlinear propagation characteristics of surface acoustic waves on an isotropic elastic solid have been studied in this paper. The solution of the harmonic boundary value problem for Rayleigh waves is obtained as a generalized Fourier series whose coefficients are proportional to the slowly varying amplitudes of the various harmonics. The infinite set of coupled equations for the amplitudes when solved exhibit an oscillatory slow variation signifying a continuous transfer of energy back and forth among the various harmonics. A conservation relation is derived among all the harmonic amplitudes.

82-2623

Phase Statistics and Phase Correlation of Sinusoidal Signals in Reverberant Rooms

K.J. Ebeling
Third Physical Inst., Univ. of Göttingen, D-3400 Göttingen, Fed. Rep. Germany, J. Sound Vib., 83 (3), pp 355-361 (Aug 8, 1982) 4 figs, 11 refs

Key Words: Sound waves, Reverberation chambers, Statistical analysis

Statistical properties of the phase in sinusoidal diffuse sound fields in reverberant rooms are considered. An exact form for the distribution density of the phase difference measured at two space points is obtained, and from second order phase statistics the spatial phase correlation function is derived. The theoretical results are examined experimentally.

82-2624

Digital Spectral Analysis of the Noise from Short Duration Impulsively Started Jets

I.S. Hodge, D.J. Smith, and N.H. Johannesen

Dept. of the Mechanics of Fluids, Univ. of Manchester, Manchester M13 9PL, UK, J. Sound Vib., 82 (2), pp 171-179 (May 22, 1982) 3 figs, 1 ref

Key Words: Spectrum analysis, Jet noise

Techniques in which a shock tube is used to produce short duration jets are discussed briefly. The method adopted involves using the shock tube as a static reservoir with the jet exhausting through a nozzle originally closed by a diaphragm. Short duration noise samples of a Mach 0 9 air jet are recorded digitally and narrow band and one-third octave spectra are evaluated. Average spectra from a number of samples are presented. Comparison with both digital and analogue spectra from the equivalent continuous jet demonstrates that it is possible to obtain meaningful spectra by averaging short duration samples of impulsively started jets.

82-2625

The Measurement of Structure-Borne Sound Transmission Using Impulsive Sources

R.J.M. Craik

Dept. of Bldg., Heriot-Watt Univ., Edinburgh, UK, Appl. Acoust., 15 (5), pp 355-361 (Sept 1982) 7 figs, 5 refs

Key Words: Structure-borne noise, Measurement techniques

A simple method to measure structure-borne sound transmission is described. Measurement is made of the level difference in the acceleration between two structural elements using a plastic headed hammer as a noise source. The method is at least as accurate as conventional measurements made under steady-state conditions using continuous noise sources and can be carried out with less instrumentation on site and in about a tenth of the time. The portability of the source greatly simplifies the measurements as a hammer can be used to hit structures in a wide variety of positions whereas shakers can be used only in limited situations.

82-2626

An Improved Method for Determination of Radiated Sound Power and Sound Transmission from Large Sources

M. Alster

FDO-Engineering Consultants, P.O. Box 379, 1000 AJ Amsterdam, The Netherlands, J. Sound Vib., 82 (2), pp 261-274 (May 22, 1982) 7 figs, 4 tables, 3 refs

Key Words: Sound power level, Sound transmission, Measurement techniques

The proposed method is an improvement of the methods for measurement of sound power level, in which the real sound source is represented by an equivalent monopole. It is based on a new concept, the equivalent acoustical center, which is introduced and defined in the paper. The main assets of the method in comparison with the existing monopole-methods are a higher accuracy, a possibility of measuring at considerably shorter distances from the noise source, and a certain freedom in the choice of the measuring points around the source.

82-2627

A Review of Structural Noise Transmission

R.H. Lyon and J.W. Slack

Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, Shock Vib. Dig., 14 (8), pp 3-11 (Aug 1982) 11 figs, 20 refs

Key Words: Noise transmission, Sound transmission, Reviews

This article characterizes theoretical and experimental analyses of noise transmission in structures. The transmission path and vibratory response are discussed, as are the uses of broadband transfer functions to estimate time-varying response and of signal processing to diagnose vibration sources and paths.

SHOCK EXCITATION

82-2628

Generalized "Shock Structure" in a Non Linear Viscoelastic Medium

A. Donato and G. Vermiglio

Istituto di Matematica dell'Universita di Messina, via Tommaso-Cannizzaro, 98100 Messina, Italy, J. de Mecanique, 1 (2), pp 359-367 (1982) 5 refs

Key Words: Shock wave propagation, Viscoelastic media

An asymptotic expansion is constructed which generalizes the classical shock structure solution in a nonlinear viscoelastic medium. The method can be used in order to obtain solutions, valid everywhere; also when a known shock line divides two different materials that are both viscoelastic or one is elastic and the other, viscoelastic.

82-2629

Diffraction of Plane SH Waves in a Half-Space

A.H. Shah, K.C. Wong, and S.K. Datta

Dept. of Civil Engrg., Univ. of Manitoba, Winnipeg, Canada, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 519-528 (July/Aug 1982) 8 figs, 1 table, 14 refs

Key Words: Shear waves, Wave diffraction, Ground motion, Discontinuity-containing media, Tunnels, Seismic waves

Scattering of antiplane shear waves in two dimensions by surface and near-surface defects in a homogeneous, isotropic elastic semi-infinite medium has been studied. Attention has been focused here in the range of medium to long wavelengths. A combined finite element and analytical technique has been used to study the problems of scattering by semicircular and triangular canyons. The results for the former case are compared with the known exact solution and those for the latter case are compared with some available approximate solutions. A problem of multiple scattering by a triangular canyon and a nearby circular tunnel is studied. Numerical results are presented showing the effects of multiple scattering and different angles of incidence.

82-2630

Simplified Shock Design for Installation of Equipment

H.A. Gaberson and R.A. Eubanks

Naval Civil Engrg. Lab., Port Hueneme, CA, Rept. No. CEL-TN-1622, 170 pp (Mar 1982)
AD-A114 331

Key Words: Hardened installations, Equipment response, Shock response

A simplified shock design method has been developed which employs the shock spectrum as the fundamental measure of both the severity of a shock environment and the hardness of a particular piece of equipment (the hardness is the equipment's capacity to survive a shock environment). Both the severity and the hardness are given as shock spectrum plots on four-coordinate paper and are thus directly comparable. The method uses a tracing method of recording the fact that the hardness exceeds the severity and thus equipment survival is assured.

VIBRATION EXCITATION

(Also see No. 2675)

82-2631

On the Self-Stressing Modes in Free Vibration Analysis

S. Idelsohn and M. Geradin

Universidad National Rosario, Argentina, J. Sound Vib., 83 (2), pp 143-155 (July 22, 1982) 2 figs, 3 tables, 10 refs

Key Words: Free vibration, Vibration analysis

The type of convergence to the eigenspectrum of a structure calculated from a finite element analysis is examined in light of the variational properties of the Rayleigh quotient and of Courant's maximum-minimum principle. The influence of the self-stressing modes on the solution is first demonstrated theoretically and then shown practically on the results obtained via a family of equilibrium elements in which the number of self-stressing modes relative to the number of vibration modes may be varied as a parameter.

82-2632

Confinement of Vibration by Structural Irregularity

C.H. Hodges

Topexpress Limited, 1 Portugal Place, Cambridge CB5 8AF, UK, J. Sound Vib., 82 (3), pp 411-424 (June 8, 1982) 5 figs, 22 refs

Key Words: Vibration control, Geometric effects

The propagation of vibrations in structures with some degree of extended disorder; i.e., departure from regularity or strict periodicity extended throughout the structure, is discussed. An account is given of the phenomenon of normal mode localization, caused under certain circumstances by the disorder. This phenomenon means that vibrational energy injected into the structure by an external source cannot

propagate to arbitrarily large distances, but is instead substantially confined to a region close to the source. Specifically, it is shown that the steady state response of the structure decays exponentially away from the source.

82-2633
Vibration of Modified Discrete Systems: The Modal Constraint Method

J.G.M. Kerstens
Space Div., Fokker B.V., Schiphol-Oost, The Netherlands, J. Sound Vib., 83 (1), pp 81-92 (July 8, 1982) 3 figs, 5 tables, 5 refs

Key Words: Lumped parameter method, Modal constraint method, Structural modification effects

In an earlier paper a method was presented for calculating eigenfrequencies and modes of a vibrating system whose modifications consist of adding point supports. In another paper generalization of the method was presented for establishing vibration characteristics for complex continuous systems which are composed of several (base or known) continuous systems. In this paper this method (the modal constraint method) is applied to discrete systems. The eigenfrequencies and modes of the base systems calculated with the aid of, for instance, the finite element method are used to establish the vibrational characteristics of the modified systems. The modifications may consist of addition or removal of base systems and/or adding supports. The reduction of work as compared with direct solving of the modified system problems is significant, especially for large degree-of-freedom problems.

82-2634
Analysis of Randomly Time Varying Systems by Gaussian Closure Technique

P.K. Dash and R.N. Iyengar
Material Sci. Div., Natl. Aeronautical Lab., Bangalore 560 017, India, J. Sound Vib., 83 (2), pp 241-251 (July 22, 1982) 4 figs, 11 refs

Key Words: Multidegree of freedom systems, Time-dependent parameters, Random response, Stochastic processes

The Gaussian probability closure technique is applied to study the random response of multidegree of freedom stochastically time varying systems under non-Gaussian excitations. Under the assumption that the response, the coefficient and the excitation processes are jointly Gaussian, deterministic equations are derived for the first two response moments. It is further shown that this technique leads to the best Gaussian estimate in a minimum mean square error sense.

82-2635
Stored Energy in an Enclosure Driven by Externally Placed Drives

G. Maidanik and L.J. Maga
David Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD 20084, J. Sound Vib., 82 (3), pp 335-344 (June 8, 1982) 5 figs, 1 table, 2 refs

Key Words: Enclosures, External reverberation, Internal reverberation, Reverberation chambers

In a recent paper a formalism was developed relating to the transition between a non-reverberant and a reverberant dynamic system. In this paper the formalism is extended to allow for externally placed drives to act on the dynamic system. A simulated example that incorporates the extension is cited. To accommodate the example the formalism is converted from its one-dimensional format to the three-dimensional format. The converted formalism is then employed to assess whether the relative contributions to the stored energy in the three-dimensional dynamic system -- an enclosure – can be deciphered by artificially modifying the reverberation state of the enclosure. The example serves to illustrate the manner by which the reverberation can be modified and the way the relative contributions can be assessed.

82-2636
Response of Self-Excited Oscillators to Multifrequency Excitations

K.R. Asfar, A.H. Nayfeh, and D.T. Mook
Yarmouk University, Irbid, Jordan, J. Sound Vib., 79 (4), pp 589-604 (Dec 22, 1982) 11 figs, 5 refs

Key Words: Van der Pol method, Harmonic excitation

The method of multiple scales is used to determine the response of a self-excited system having a single degree of freedom to multi-frequency harmonic excitations. Many cases, including combination and simultaneous resonances, are considered. The perturbation results are found to be in good agreement with those obtained by numerically integrating the governing differential equation. The response consists of two parts – a forced oscillation part and a free oscillation part with an amplitude and phase that are functions of the excitations.

DAMPING

82-2637

Dynamic Behaviour of a Damper Consisting of a Saturated Porous Medium (Comportement Dynamique d'un Amortisseur Compose d'un Milieu Poreux Sature)

J.L. Auriault and C. Avallet

Institut de Mecanique de Grenoble, B.P. 53 X, 38041 Grenoble Cedex, J. de Mecanique, 1 (2), pp 269-290 (1982) 4 figs, 5 graphs, 1 table, 11 refs

(In French)

Key Words: Dampers, Porous materials

By means of the method of homogenization of a small periodical porous matrix, equations are obtained which describe the macroscopic dynamic behavior of an elastic porous solid saturated by a newtonian viscous fluid. Theoretical results are compared with experimental data from a saturated porous damper with periodical matrix. The dynamic permeability of the damper is calculated.

82-2638

Distinctions between Boundary and Distributed Damping in a Waveguide with a Cutoff Frequency

P.W. Smith, Jr.

Bolt, Beranek and Newman, Inc., Cambridge, MA 02138, J. Acoust. Soc. Amer., 72 (2), pp 472-475 (Aug 1982) 3 figs, 8 refs

Key Words: Waveguide analysis, Damping effects

The precise, closed-form solution for response of a finite one-dimensional waveguide with cutoff (string on an elastic foundation) is examined for cases where damping is either uniformly distributed or concentrated in the ends. No marked spatial concentration of response at the driven point is found unless the damping is distributed and also the wave attenuation in one round trip through the system is large. Increased dispersion, as frequency approaches the cutoff, increases the round-trip attenuation caused by distributed viscous damping, but it decreases the attenuation caused by boundary damping (at the ends of the waveguide).

82-2639

Torsional Damper for Maximum Energy Absorption with Equilibrated Polydimethylsiloxanes as Damping Fluids

R. Andrä and J.H. Spurk

Technische Hochschule Darmstadt, Technische Strömungslehre, D6100 Darmstadt, Germany, J. Sound Vib., 82 (4), pp 465-472 (June 22, 1982) 7 figs, 4 refs

Key Words: Viscous damping, Torsional vibration

Shear viscosity and effective shear modulus, quantities related to the complex viscosity, have been measured as functions of frequency for five polydimethylsiloxanes commonly used as damper fluids. Maximum energy dissipation is obtained by realizing a damper whose damping constant times the shear viscosity divided by the product of effective shear modulus and moment of inertia of the inertia member equals one. Experiments show that in this tuning the dissipated energy when polydimethylsiloxanes are used as damping fluids can be as much as a factor of two higher than the maximum dissipated energy when using Newtonian fluid.

82-2640

Development of Vibration Dampers that Reduce Riveting Noise in Aircraft Construction

N. Kosuch

Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Fed. Rep. Germany, Rept. No. BMFT-FB-HA-81-017, 63 pp (Dec 1981)

N82-22503

(In German)

Key Words: Vibration dampers, Noise reduction, Construction industry, Aircraft

The origin and properties of riveting noise were examined. Vibration absorbers for the reduction of noise levels during riveting on thin metal sheets were developed. Commercial damping materials were used in conjunction with fastening by negative pressure.

FATIGUE

82-2641

Fatigue Strength under Multi Axial Excitation -- Possibilities and Limits of the Torsional Stress Intensity

Hypothesis (Dauerschwingfestigkeit bei mehrachsiger Beanspruchung - Möglichkeiten und Grenzen der Schubspannungsintensitätshypothese)
J.O. Nökleby and A.O. Walöen
Det norske Veritas, Oslo, Norway, Konstruktion, 34 (8), pp 311-312 (Aug 1982) 2 figs, 5 refs
(In German)

Key Words: Fatigue life, Torsional excitation

The torsional stress intensity hypothesis for the calculation of fatigue strength under multiaxial excitation is discussed. Different versions of the hypothesis, its possibilities and its limitations, are described. The authors observe that the basic three-dimensional version of the hypothesis has more advantages and fewer disadvantages than the others.

ELASTICITY AND PLASTICITY

82-2642
Dynamic Fracture of Idealized Fiber-Reinforced Materials
L.F. Mannion
Ph.D. Thesis, Brown Univ., 106 pp (1981)
DA8215589

Key Words: Fracture properties, Fiber composites, Beams

A model for the dynamic fracture of a material reinforced by two orthogonal sets of straight, parallel fibers is presented. The model is a continuum theory, in the sense that no distinction is made between particles lying on a fiber or in the matrix; the fibers are assumed to be inextensible and continuously distributed. The theory may be interpreted as an asymptotic approximation to anisotropic elasticity.

82-2643
An Experimental Investigation into the Mechanics of Dynamic Fracture
K. RaviChandar
Ph.D. Thesis, California Inst. of Tech., 136 pp (1982)
DA8213901

Key Words: Fracture properties, Crack propagation

Current theories of dynamic fracture are based on elastodynamic analyses of mathematically sharp plane cracks and as such do not explain the observed terminal velocities or the phenomenon of crack branching satisfactorily. The present investigation addresses the above problems by using both microscopic and macroscopic interpretations. The experimental scheme that is used in this investigation is the configuration of a pressure loaded semi-infinite crack in an infinite medium. The loading is achieved through an electromagnetic device which provides highly repeatable loading. The method of caustics is used in conjunction with a high speed camera to obtain the time histories of the crack tip stress intensity factor and the crack position. The problems of crack initiation and crack arrest are explored.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 2529, 2533, 2611, 2616, 2677)

82-2644
Electro Optical Transducer for Monitoring Biaxial Displacement
G.E. Warren
Naval Civil Engrg. Lab., Port Hueneme, CA, Exptl. Techniques, 6 (4), pp 1-3 (Aug 1982) 6 figs, 1 table, 6 refs

Key Words: Measuring instruments, Transducers

Dual-axis, position-sensitive, semiconductor detectors are described which can be employed as deflection-measurement alternatives to mechanical and LVDT devices. A position sensor provides a continuous, direct electrical analog of the X and Y displacement of a light spot moving across its active area. With appropriate optics and electronics, biaxial position sensors can be used for measuring dynamic, lateral and angular displacements of inaccessible structures.

82-2645
A Real-Time Active Vibration Controller
M.R. Serbyn and W.B. Penzes
Ctr. for Manufacturing Engrg., Natl. Bureau of Standards, ISA Trans., 21 (3), pp 55-59 (1982) 7 figs, 5 refs

Key Words: Interferometers, Active vibration control, Real time spectrum analyzers

The Michelson interferometer is viewed as a noisy system whose noise input results from unwanted changes in the optical path lengths of its beams, and whose desired output is a constant optical path-length difference. A technique for maintaining this quality at a value equal to a multiple of quarter wavelengths of the light is described.

82-2646

Analysis and Design of Periodically Time-Varying Digital Filters

C.M. Loeffler

Ph.D. Thesis, Rice Univ., 134 pp (1982)

DA8216337

Key Words: Digital filters, Time-dependent parameters

A description of periodically time-varying systems was developed which completely characterizes the relationship between the spectra of the input and output signals of these systems. The description is the bi-frequency map. This description completely separates the time-invariant and time-varying portions of the system. It can be used to analyze each of these portions of the system.

82-2647

A Quick and Simple Method for Estimating the Transmission or Insertion Loss of an Acoustic Filter

S. Soderqvist

IFM Akustikbyran, Warfvinges Vag 26, S-112 51 Stockholm, Sweden, Appl. Acoust., 15 (5), pp 347-354 (Sept 1982) 9 figs

Key Words: Acoustic filters, Sound transmission loss, Sound insertion loss

A method is presented by which the dominating term in the expression for TL or IL can be set up without using the complete equation system. This dominating term is the one that contains the highest power of A_c/A_p (chamber area divided by pipe area). The approximation is valid everywhere except at the filter resonances where sine and cosine factors contained in the term tend to zero. The approximation is also invalid at low frequencies where the length of chambers and pipes is smaller than about 12.5 percent of the wavelength. If this frequency region is of interest a lumped-element description of the filter can be used.

82-2648

ACORA -- A Computer-Aided System of Instruments for Real-Time Signal Analysis During Transient Operation (ACORA -- Ein Messsystem zur schnellen Signalanalyse bei instationären Fahrzustanden)

J. Kolerus

Automobiltech. Z., 84 (7/8), pp 371-376 (July/Aug 1982) 4 figs, 1 table, 5 refs

(In German)

Key Words: Real time spectrum analyzers, Vibration analyzers, Ground vehicles

ACORA (Akustic Computer Real Time Analyzer) is a mobile system for analysis of sounds and vibrations from vehicles operating in transient states. It was developed for Volkswagen AG based on experience with off-line computation. There are two remarkable features of the system: its extremely high data-acquisition rate and its versatility as a module in different applications. It is designed for use in many departments: research and development, quality control and production control. This article describes aspects of the system relevant for the user, giving typical examples of its application.

82-2649

A New Approach to the Integration of Accelerometer Data

D.M. Trujillo and A.L. Carter

Trucomp, Fountain Valley, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 529-535 (July/ Aug 1982) 3 figs, 4 refs

Key Words: Accelerometers, Data processing

A direct approach to the integration of accelerometer data is presented which depends only on the fact that the final velocity and possibly, the final displacement are known. Using a dynamic programming formulation, the accelerometer record is corrected to account for these cases. The formulation is presented for the general case where velocity, displacement, as well as accelerometer data, are available. A numerical example is included.

82-2650

Systematic Measurement Errors with Two Microphone Sound Intensity Meters

J.C. Pascal and C. Carles

Laboratoire d'Acoustique, Conservatoire National des Arts et Métiers, 292 Rue Saint Martin, 75003

Paris, France, J. Sound Vib., 83 (1), pp 53-65 (July 8, 1982) 8 figs, 22 refs

Key Words: Sound level meters, Error analysis

Acoustic intensity meters in which two closely spaced microphones are used are sensitive to an instrumental convolution effect due to the finite difference approximation. This consequence of the working principle leads to a theoretical high frequency cut-off. Two methods are available to obtain the approximate intensity: the direct two microphone method and the sum-difference method. In all cases, it is shown that phase distortions induced by measuring equipment affects the intensity meter frequency response and its directivity pattern. In addition, specific phase mismatch with the second method render intensity measurements sensitive to reactive fields. From this analysis, requirements are deduced for equipment design.

82-2651

Phase Shift Errors in the Theory and Practice of Surface Intensity Measurements

M.C. McGary and M.J. Crocker

NASA Langley Res. Ctr., Hampton, VA 23665, J. Sound Vib., 82 (2), pp 275-288 (May 22, 1982) 13 figs, 16 refs

Key Words: Noise path diagnostics, Noise source identification, Acoustic intensity method, Cross spectral method

The surface acoustical intensity method (sometimes known as the microphone-accelerometer cross-spectral method) is a relatively new noise source/path identification tool. Several researchers have had difficulties implementing this method because of instrumentation phase mis-match. A simple technique for measuring and correcting instrumentation phase mis-match has been developed. This new technique has been tested recently on a noise source identification problem of practical interest. The results of the experiments indicate that the surface acoustic intensity method produces reliable data and can be applied to a variety of noise source/path problems.

82-2652

Rotating Valve for Velocity-Coupled Combustion Response Measurements

R.S. Brown, R.C. Waugh, and V.L. Kelly

United Technologies, Sunnyvale, CA, J. Spacecraft, 19 (5), pp 437-444 (Sept-Oct 1982) 13 figs, 1 table, 29 refs

Key Words: Solid rocket propellants, Acoustic response, Measurement techniques

A dual rotating valve apparatus has been investigated for measuring the velocity-coupled response function of solid propellants. Bulk mode velocity oscillations are generated by operating rotating valves 180 deg out of phase at each end of a combustion chamber. Analytical studies were conducted using both a linear and a nonlinear velocity-coupling model to demonstrate feasibility and to develop data reduction methods. A method for extracting the linear response from oscillatory pressure measurements was demonstrated.

82-2653

An Instrument for Vibration Mode Analysis Using Electronic Speckle Pattern Interferometry

A.P.M. Hurden

Electro-optics Div. of W. Vinten Ltd., Western Way, Bury St. Edmunds, Suffolk IP33 3TB, UK, Non-destructive Testing Intl., 15 (3), pp 143-148 (June 1982) 12 figs, 18 refs

Key Words: Measuring instruments, Vibration measurement, Electronic test equipment, Proximity probes

The use of electronic speckle pattern interferometry as a non-destructive testing technique for measuring small displacements of a variety of objects has been widely reported. A description is given of an instrument which, with the use of a micro-computer, can now produce an isometric view of an object vibrating in a resonant mode, thus making the results easier to interpret. The instrument provides a real-time, non-contacting alternative to other mode analysis equipment and can detect high-order modes as easily as low-order modes.

82-2654

Selecting Dynamic Instrumentation

W. Tustin

Tustin Inst. of Tech., Santa Barbara, CA, Test, 44 (4), pp 10, 12, 13 (Aug/Sept 1982) 7 figs

Key Words: Vibration measurement, Measuring instruments

Vibration instrumentation for use in sinusoidal vibration testing, random testing, shock testing, or for measuring transportation or service vibration is described.

82-2655
Studying Sources of Brake Noise with Coherent Optical and Holographic Measuring Techniques
A. Felske
Natl. Inst. for Transport and Road Res., Pretoria, South Africa, 18 pp (Oct 1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)
PB82-206152

Key Words: Brakes (motion arresters), Noise generation, Vibration analysis, Vibration measurement, Holographic techniques

The analysis of vibrations on squealing brake systems is mainly covered by new optical measuring techniques: laser doppler velocimetry, image derotation and holographic interferometry. Noise sources can be localized, elaborated vibration centers can be measured quantitatively by the sensitive laser doppler technique on rotating and non-rotating components. Demonstrating the efficiency of these methods some results in preventing brake squeal of disk and drum brakes are discussed.

82-2656
Ultrasonic Imaging System Using Coppler-Modulated Wave Fronts
O. Sasaki, Y. Kirii, and Y. Kitazawa
Niigata Univ., Faculty of Engrg., 8050 Ikarashi 2, Niigata-shi, Japan, J. Acoust. Soc. Amer., 72 (2), pp 431-435 (Aug 1982) 9 figs, 4 refs

Key Words: Vibration analysis, Signal processing techniques, Ultrasonic techniques, Holographic techniques

A new imaging method is proposed which reconstructs a stationary image at any time of a vibrating object from a hologram synthesized with Fourier coefficients of the detected signal over a few periods of the vibration. This signal arises from receiving time-varying ultrasonic waves frequency shifted by the Doppler effect. The signal processing of the new method produces some special features such as reduction of noise, elimination of stationary objects, and selective reconstruction of the object vibrating with a specified frequency. The computer simulations and the basic experimental results show the effectiveness of the imaging method.

82-2657
Acoustic Modal Analysis Experiment
J.J. Nieter and R. Singh
Dept. of Mech. Engrg., Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 72 (2), pp 319-326 (Aug 1982) 7 figs, 1 table, 21 refs

Key Words: Modal analysis, Ducts, Mufflers, Resonators, Measurement techniques, Natural frequencies, Mode shapes

This paper proposes an experimental modal technique for acoustic ducts, mufflers, and resonators over the plane-wave frequency regime. Global modal properties, such as natural frequencies and modes of gas oscillation, are extracted from the coincident-quadrature response curves of measured cross-point acoustic impedances at a number of observation locations. The acoustic system is excited by a vibrating piston which is driven by an electromagnetic shaker with band-limited binary random noise signal. The acoustic impedance is determined using two transducers: an accelerometer attached to the piston -- its signal is processed to yield volume velocity information, and a microphone traverse. Digital data acquisition and processing techniques are used to generate the necessary impedance data at a number of locations for modal analysis.

82-2658
Non-Stationary Random Responses of a Multi-Degree-of-Freedom System by the Theory of Evolutionary Spectra
C.W.S. To
Dept. of Mech. Engrg., Univ. of Calgary, Calgary, Alberta, Canada T2N 1N4, J. Sound Vib., 83 (2), pp 273-291 (July 22, 1982) 5 figs, 1 table, 18 refs

Key Words: Multi degree of freedom systems, Random response, Spectrum analysis

General expressions for the closed form transient receptance, evolutionary spectral and cross-spectral densities required in the non-stationary random analysis of structures, discretized by the finite element method, to non-stationary random excitations are presented. Application of the derived results to the non-stationary random analysis of a mast antenna structure subjected to base excitations treated as a uniformly modulated random process is made. The computed results of evolutionary spectral and cross-spectral densities are presented graphically.

82-2659
Frequency Analysis of Structures by Integrated Force Method
S.N. Patnaik and S. Yadagiri

INSAT, Space Segment Project Office, Dept. of Space, Bangalore, India, J. Sound Vib., 83 (1), pp 93-109 (July 8, 1982) 9 figs, 7 tables, 13 refs

Key Words: Frequency analysis, Integrated force method

The integrated force method (IFM) is extended to vibration analysis of structures, with the concept of force mode shape used as the primary analysis variable. The potential of IFM to simplify structural design under frequency constraint is illustrated. Frequency analysis by IFM is illust.ated by taking examples such as a spring mass system, a truss, a beam and a plate. The necessity to develop an energy expression for IFM is pointed out.

82-2660
Free Vibration Analysis of Coupled Structures by Modal Synthesis (Schwingungsberechnung zusammengesetzter Systeme durch modale Synthese)
P. Ruge
Mechanikzenstrum, Lehrstuhl f. Mechanik und Festigkeitslehre der TU Braunschweig, Pockelsstrasse 4, D-3300 Braunschweig, Bundesrepublik Deutschland, Ing. Arch., 52 (3/4), pp 177-182 (1982) 2 figs, 2 tables, 6 refs
(In German)

Key Words: Modal synthesis, Substructuring methods, Component mode synthesis

Substructure coupling by component mode synthesis leads to a rational algebraic eigenvalue problem with series of partial fractions. An iterative process using the trace-theorem is given along with a method to avoid poles.

SCALING AND MODELING

82-2661
Design of Dynamically-Scaled, Asymmetrical Wind Tunnel Models
M.E. Beyers
Natl. Inst. for Aeronautics and Systems Tech., Pretoria, South Africa, Rept. No. NIAST-78/18, 18 pp (Aug 6, 1981)
N82-22285

Key Words: Scaling, Test models, Wind tunnel testing, Wing stores

Dynamically scaled models are used in aerodynamic studies, notably in aircraft/store or stage separation studies. Techniques were developed for the design of free flight models in three general categories: dynamic stability free flight models, high maneuverability models optimized for non-oscillatory motion studies, and dynamic separation models. Dynamic scaling with fully simulated mass asymmetries play an important part in each of the three categories, particularly when nonplanar motions are simulated.

BALANCING

82-2662
Evaluation of a Balancing Machine Performance
S.G. Braun, B.B. Seth, and N.L. Field
Metal Forming and Joining Dept., Ford Motor Co., Dearborn, MI 48239, J. Sound Vib., 83 (3), pp 301-312 (Aug 8, 1982) 2 figs, 3 tables, 8 refs

Key Words: Balancing machines, Rigid rotors

A systematic approach for the characterization of a balancing machine performance is described. The objective of this study is to determine the achievable accuracy in balancing similar rigid rotating machines. Along with the theoretical work, experimental examples are presented for the identification of calibration, random and systematic inaccuracies.

MONITORING

82-2663
Rotating Tool Wear Monitoring Apparatus
K.W. Yee
Dept. of Commerce, Washington, DC, U.S. Patent Appl. No. 6-364 944, 19 pp (Apr 2, 1982)

Key Words: Monitoring techniques, Wear, Computer-aided techniques

A system is provided for predicting when the failure of a rotating machine tool or part is imminent or when a tool is worn. The system includes a transducer for producing an output related to the workpiece vibrations caused by the machine tool and an analog comparator which compares this output with a threshold signal related to the normal operation of the tool and established by a microcomputer which determines whether further signals which exceed the threshold are produced during each of a predetermined number of subsequent time intervals related to the rotational

speed of the tool. If so, a 'failure' signal is produced which may be used, for example, to cause retraction of the tool.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 2493)

82-2664

A Newtonian Procedure for the Solutions of $Ex=\lambda Ax$

A. Simpson
Dept. of Aeronautical Engrg., Univ. of Bristol, Bristol BS8 1TR, UK, J. Sound Vib., 82 (2), pp 161-170 (May 22, 1982) 1 fig, 3 refs

Key Words: Eigenvalue problems

Newtonian iteration on a scalar function, which is obtained by condensation of the pencil $E-\lambda A$, is used in conjunction with Sturm sequence properties of the pencil to provide an infallible, quadratically convergent algorithm for all eigenvalues of $A^{-1}E$ within any stated λ-range. The algorithm has been programmed for use on a desk-top machine and large (sparse matrix) eigenvalue problems have been solved. A brief outline of the essential steps in the program is given along with some particular solutions.

82-2665

Lagrangian Formulation and First Integrals of Piecewise Linear Dissipative Systems

F. Badrakhan
College of Engrg. and Petroleum, Kuwait Univ., Kuwait, J. Sound Vib., 82 (2), pp 227-234 (May 22, 1982) 2 figs, 9 refs

Key Words: Oscillators, Damped structures, Lagrange equations

The Lagrangian description of the motion of a damped oscillator is used as a starting point for deducing the canonical formulation and studying the existence of first integrals according to Noether's generalized theorem. It is shown that first integrals exist only if the restoring force is linear. Finally, results are applied to the study of some important linear or piecewise-linear cases such as the Reid oscillator and the oscillator with bilinear hysteresis.

82-2666

Bounds on the Eigenvalues for Certain Classes of Dynamic Systems

M.A. Zeid
Ph.D. Thesis, Michigan State Univ., 173 pp (1982)
DA8216603

Key Words: Eigenvalue problems, Boundary value problems, Bond graph technique

To estimate bounds on the eigenvalues of a system from a pictorial model, classical methods were used to derive the state equations; then from the state matrix the bounds on the largest eigenvalue were obtained. For a class of systems, the bounds on the largest real part and the largest imaginary part of the eigenvalues were obtained by inspecting a graphical model of these systems. The graphical model used is a canonical form of the bond graph; namely the gyrobondgraph. The yield of this work is the reduction in the computational effort required to obtain the bounds. This reduction becomes of major importance when the bounds are estimated for large scale systems.

82-2667

Almost Sure Stable Oscillations in a Large System of Randomly Coupled Equations

S. Geman
Div. of Appl. Math., Brown Univ., Providence, RI 02912, SIAM J. Appl. Math., 42 (4), pp 695-703 (Aug 1982) 1 fig, 7 refs

Key Words: Differential equations, Random parameters

This paper is about limiting (large system) behavior of a set of differential equations with random coefficients. Under certain conditions the behavior of the entire system is well described by a small number of prototype equations, and these can be derived, heuristically, by applying a law of large numbers to the original system. An application of this theorem is the specification of a small number of parameters which guarantee that sufficiently large versions of the systems studied will oscillate with a predicted period and wave form.

82-2668

Distribution of the Natural Frequencies in Matrix-Characterized Structures

M.E. Gaylard

Dept. of Mech. Engrg., Brunel Univ., Uxbridge UB8 3PH, UK, J. Sound Vib., 82 (3), pp 435-444 (June 8, 1982) 5 figs, 20 refs

Key Words: Natural frequencies, Matrix methods, Stiffness coefficients, Mass coefficients

The distribution of the natural frequencies has a recognized importance in the statistical energy analysis of vibrations of continuous structures. A method is introduced for approximating to the distribution of the natural frequencies for structures characterized by matrices of stiffness and mass coefficients, without resolving specific frequencies. Simple examples are given. Potential uses include frequency analysis for incompletely defined or sampled structural matrices.

82-2669

Parametric Excitation Stability via Hamilton's Action Principle

J.G. Papastavridis

School of Engrg. Sci. and Mech., Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 82 (3), pp 401-410 (June 8, 1982) 1 fig, 17 refs

Key Words: Parametric excitation, Hamiltonian principle

A Hamilton's principle based direct variational method for the asymptotic determination of the well-known stability/instability boundaries of Mathieu's equation is presented. The presence of time-dependent parameters in the system of the Lagrangian necessitates a generalization of the conventional Hamilton's principle: this consists in treating these variable system parameters as additional generalized co-ordinates, and subjecting them to similar variations. The interpretation of the resulting energetic expressions leads to the formulation of a new time-integral-of-energy stability criterion and a parametric invariance theorem. Its relation/equivalence with existing non-conservative system energy tests is pointed out.

NUMERICAL METHODS

(Also see Nos. 2614, 2620)

82-2670

On the Structure of Duffing's Equation without Dissipation (Sur La Structure d L'Equation de Duffing sans Dissipation)

B.V. Schmitt

Dept. of Math., Univ. de Metz, Ile du Saulcy, 5700 Metz, France et Institut de Recherche Mathématique Avancée, 7 rue René-Descartes, 67084 Strasbourg, France, Siam J. Appl. Math., 42 (4), pp 868-894 (Aug 1982) 21 figs, 4 tables, 14 refs

(In French)

Key Words: Numerical analysis, Duffing's differential equation

Certain types of periodic harmonic and subharmonic solutions of Duffing's equation are determined numerically without dissipation – even solutions or solutions which are out of phase by $\pi/2$ from an odd function. The numerical technique used, which is new and very simple, is explained in detail. It is based on the symmetries of the equation and of the periodic solutions sought for. The results are presented in the form of graphs which show the initial conditions and the stability (for the harmonics) of the periodic solutions in the space of parameters of the equations.

82-2671

Another Kind of Numerical Instabilities of the Integral Approach to the Interior Boundary-Value Problem for the Two-Dimensional Helmholtz Equation

F. Mattioli

Istituto di Geofisica dell'Universita di Bologna, Bologna, Italy, Intl. J. Numer. Methods Engrg., 18 (8), pp 1115-1130 (Aug 1982) 3 figs, 15 refs

Key Words: Numerical analysis, Boundary value problems, Helmholtz integral method, Harbors, Wave forces

In a previous paper it has been proved that the integral equations arising from the application of Green's formula to the Helmholtz equation in a limited domain can show a certain type of numerical instability, if a real Green's function is used. It has been also proved that such instabilities cannot arise if a complex Green's function is employed. However, it has been found in the latter case that numerical instabilities can occur. This has been proved and thoroughly analyzed for a circular domain, and a technique of avoiding these instabilities has been devised. When this technique is followed, very accurate results can be obtained, regardless of wavenumber used.

82-2672

Error Growth in Transient Large Displacement Calculations

J.P. Wright and J.L. Baylor

Weidlinger Associates, East 59th St., New York, NY, Intl. J. Numer. Methods Engrg., 18 (8), pp 1131-1143 (Aug 1982) 8 figs, 2 tables, 13 refs

Key Words: Numerical analysis, Nonlinear response, Error analysis

Nonlinear problems are widely acknowledged as being more difficult to solve numerically than linear problems. Various kinds of errors contribute to this difficulty and in this paper some of these errors will be described and illustrated by solving certain large displacement problems using eight-noded isoparametric brick elements in space and an explicit integration method in time. Approximation errors in time integration are illustrated, with violation of energy conservation being used as an indicator of the increased difficulties encountered in solving large displacement problems. Round-off errors and order of operations are discussed and illustrated for the case of a cube that is impulsively set in rotation about its center of mass. Finally, approximation errors in spatial discretization, especially those associated with incomplete or inconsistent integration over the element volume, are illustrated for a large deflection beam problem.

82-2673

Scattering of Rayleigh Surface Waves by Edge Cracks: Numerical Simulation and Experiment

M. Hirao and H. Fukuoka

Dept. of Mech. Engrg., Faculty of Engrg. Science, Osaka Univ., Toyonaka, Osaka 560, Japan, J. Acoust. Soc. Amer., 72 (2), pp 602-606 (Aug 1982) 7 figs, 12 refs

Key Words: Wave diffraction, Cracked media, Numerical analysis

Scattering of Rayleigh surface waves by surface edge cracks is numerically simulated in a two-dimensional geometry, using the finite-difference method and the FFT algorithm. The numerical solutions are in good agreement with the experimental observations based on the ultrasonic spectrum analysis and the time-of-flight measurements for the artificial cracks in mild-steel test pieces.

82-2674

The ρ-Family of Algorithms for Time-Step Integration with Improved Numerical Dissipation

G. Bazzi and E. Anderheggen

Swiss Fed. Inst. of Tech., Zurich, Switzerland, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (4), pp 537-550 (July/Aug 1982) 8 figs, 2 tables, 18 refs

Key Words: Numerical analysis, Finite element techniques, Equations of motion, Time domain method, Nonlinear systems

The dynamic analysis of complex nonlinear structural systems by the finite element approach requires the use of time-step algorithms for solving the equations of motion in the time domain. Both an implicit and an explicit version of such a time-step algorithm, called the ρ-method, the parameter ρ being used for controlling numerical damping in the higher modes, are presented in this paper. For the implicit family of algorithms unconditional stability, consistency, convergence, accuracy and overshoot properties are first discussed and proved. On the basis of the algorithmic damping ratio (dissipation) and period elongation (dispersion) the ρ-method is then compared with the well-known implicit algorithms of Hilber, Newmark, Wilson, Park and Houbolt.

82-2675

An Approximate Method of Analysis of Parametric Vibration

J. Zajaczkowski

Lodz Technical Univ., Lodz, Zwirki 36, Poland, J. Sound Vib., 79 (4), pp 581-588 (Dec 22, 1981) 4 tables, 8 refs

Key Words: Approximation methods, Parametric excitation

This paper is concerned with the stability of vibration of parametrically excited systems. A simple approximate procedure is proposed for determining the characteristic exponents of a set of linear differential equations with periodically varying coefficients.

STATISTICAL METHODS

(Also see No. 2623)

82-2676

Improvement of the Method of Statistical Energy Analysis for the Calculation of Sound Insulation at Low Frequencies

A. Elmallawany

Bldg. Res. Ctr., El Tahreer St., Dokky, P.O. Box 1770, Cairo, Egypt, Appl. Acoust., 15 (5), pp 341-345 (Sept 1982) 5 figs, 7 refs

Key Words: Statistical energy methods, Sound transmission loss, Walls, Low frequencies

In the application of the statistical energy analysis theory to the calculation of sound insulation it has been determined that there is a great discrepancy between the measured and theoretical values at low frequencies. This is one of the disadvantages of statistical energy analysis. Therefore, it was necessary to improve this method at low frequencies. The measured and theoretical values of the sound transmission loss at low frequencies are made to reach good agreement by the introduction of a correction factor.

PARAMETER IDENTIFICATION

82-2677

Modal Vector Estimation for Closely Spaced Frequency Modes

R.R. Craig, Jr., Y.T. Chung, and M. Blair

Univ. of Texas at Arlington, Arlington, TX, Rept. No. NASA-CR-162001, 41 pp (Feb 1, 1982) N82-22517

Key Words: Modal analysis, Parameter identification technique

Techniques for obtaining improved modal vector estimates for systems with closely spaced frequency modes are discussed. In describing the dynamical behavior of a complex structure modal parameters are often analyzed: undamped natural frequency, mode shape, modal mass, modal stiffness and modal damping. From both an analytical standpoint and an experimental standpoint, identification of modal parameters is more difficult if the system has repeated frequencies or even closely spaced frequencies. By employing band selectable analysis (zoom) techniques and by employing Kennedy-Pancu circle fitting or some multiple degree of freedom curve fit procedure, the usefulness of the single shaker approach can be extended.

82-2678

Large Modal Survey Testing Using the Ibrahim Time Domain Identification Technique

S.R. Ibrahim and R.S. Pappa

Old Dominion Univ., Norfolk, VA, J. Spacecraft, 19 (5), pp 459-465 (Sept-Oct 1982) 5 figs, 3 tables, 6 refs

Key Words: Parameter identification technique, Time-domain method, Plates, Rectangular plates

The ability of the Ibrahim time domain identification algorithm to identify a complete set of structural modal parameters, using a large number of free-response time histories simultaneously in one analysis and assuming an identification model with a high number of degrees of freedom, has been studied. Identification results using simulated free responses of a uniform rectangular plate, with 225 measurement stations, and experimental responses from a ground vibration test of the long duration exposure facility Space Shuttle payload, with 142 measurement stations, are presented.

MOBILITY/IMPEDANCE METHODS

82-2679

On Effective Mobilities in the Prediction of Structure-Borne Sound Transmission between a Source Structure and a Receiving Structure, Part I: Theoretical Background and Basic Experimental Studies

B. Petersson and J. Plunt

Dept. of Bldg. Acoustics, Chalmers Univ. of Tech., S-412 96 Gothenburg, Sweden, J. Sound Vib., 82 (4), pp 517-529 (June 22, 1982) 13 figs, 9 refs

Key Words: Mobility functions, Sound transmission, Structure-borne noise

The general mobility matrix formulation of the problem of multi-point, coupled structures is discussed and some of the disadvantages are emphasized. Two principally different ways of rearranging the general mobility matrix into corresponding effective mobilities, useful for expressing the vibratory power input to the receiving structure, are investigated theoretically. The two concepts of effective mobility; namely effective point mobility in which the points are considered individually with the interaction between the points taken into account and effective overall mobility in which a space averaged point mobility is deduced, have also been verified experimentally.

82-2680

On Effective Mobilities in the Prediction of Structure-Borne Sound Transmission between a Source Structure and a Receiving Structure, Part II: Procedures for the Estimation of Mobilities

B. Petersson and J. Plunt

Dept. of Bldg. Acoustics, Chalmers Univ. of Tech., S-142 96 Gothenburg, Sweden, J. Sound Vib., 82 (4), pp 531-540 (June 22, 1982) 13 figs, 11 refs

Key Words: Mobility functions, Sound transmission, Structure-borne noise

The structure-borne sound power transmission between multi-point, coupled structures can theoretically be described by effective mobility. The results from full scale measurements of transfer and point mobilities of compound structures show that in some cases the effective point mobility can be approximated by the ordinary point mobility. Estimation procedures for the ordinary point mobilities containing manageable expressions for engineering applications have been developed and some examples are presented. The basic reasoning behind these procedures are described.

COMPUTER PROGRAMS

82-2681

Description of a Simulation System DYSIM for Continuous Dynamic Processes

P. la Cour Christensen

Risoe Natl. Lab., Roskilde, Denmark, 27 pp (Jan 1981)

RISO-M-2271

Key Words: Computer programs, DYSYS (computer programs), Simulation

A general purpose simulation system DYSIM for continuous dynamic processes has been worked out. The new system has been made in order to improve the performance by excluding unused features and including new ones, and speed up the computations by a careful programming of the essential routines for integration and administration.

82-2682

Engine Dynamic Analysis with General Nonlinear Finite Element Codes, Part II: Bearing Element Implementation, Overall Numerical Characteristics and Benchmarking

J. Padovan, M. Adams, D. Fertis, I. Zeid, and P. Lam

The Univ. of Akron, Akron, OH, ASME Paper No. 82-GT-292

Key Words: Computer programs, Finite element technique, Engines, Rotors

In an attempt to increase jet engine efficiencies, typically smaller rotor-stator-running clearances are being employed. Because of this and the ever present need to improve maintenance, reliability and structural integrity under various modes of operation, more sophisticated analysis tools are required to model the engine. Due to the widespread usage of general purpose finite element codes, this paper seeks to adapt the procedure to use in modeling turbine rotor-bearing-stator structure.

GENERAL TOPICS

CRITERIA, STANDARDS, AND SPECIFICATIONS

82-2683

Transportation Noise, Its Impact, Planning and Regulation

J. Manuel

Ontario Ministry of the Environment, Toronto, Ontario, Canada, 21 pp (Oct 1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)

PB82-206111

Key Words: Traffic noise, Noise reduction, Regulations

An overview of the different sources of transportation noise in urban environments, the noise levels, human response to noise, and remedial actions taken to reduce noise pollution is presented.

82-2684

Noise Regulation and Enforcement

J. Manuel

Ontario Ministry of the Environment, Toronto, Ontario, Canada, 19 pp (Oct 1981) (Pres. at Intl. Symp. on Transportation Noise, CSIR Conf. Ctr., Pretoria, Oct 21-23, 1981)

PB82-206103

Key Words: Traffic noise, Noise reduction, Regulations

This paper discusses the development and implementation of the environmental noise control program in Ontario. It discusses the legislation, the delegation of powers to other political units, and the development of policy. The assessment and approval of new land uses and new industrial and commercial projects is also described. The paper demonstrates the need for a strong enforcement policy and the need for regular transfer of technology and for public education. Control of occupational noise and deficiencies in the construction codes with respect to noise control in Ontario is also discussed.

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1190	1591	1192	1003	364	1005	1416	1187	808	629
1410	1681	1592	1413	804	1415	2156	1337	1188	749
1680	1921	1922	1593	1004	1925		1677	1678	809
1920	2291		1923	1774	2155		2287	2548	1189
2030			2163	1924	2455				1339
2370				2044					1679
									2059
									2369

Beat Frequency

		332							
		732							

Belt Drives

					365				

Belts (Moving)

								1198	

Bernoulli-Euler Method

		122				646			

Bibliographies

250	251	252	253	1334	1335	1576	1577	248	249
550	551	552	553	1574	1575			548	549
1130	1131	1332	1333	1844				938	1129
1330	1331	1582	1843	2314				1328	1329
1580	1581	1842						1578	1579
1840	1841							2488	2489

Bicycles

									579

Bifurcation Theory

	2471		463	914					

Bimodular Properties

									2569

Bird Strikes

						2366	2557	598	
								1918	

Blade Loss Dynamics

			543	544				288	259
								1408	

Blades

620	101	102	623	524	625	606	357	358	619
800	261	622	803	604	1575	626	627	538	669
1000	621	802	1673	624	1675	1186	1387	598	799
1140	801	1002	2153	1164	2555	1626	1917	798	1079
2360	1001	2362	2363	1594		1676	2367	1918	1409
	1791	2492	2553	1674		1916	2557	2358	1919
	2361	2552		2054		2366		2558	2559
				2254		2556			
				2364					
				2554					

Blast Effects

						1066			

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
Volume 14												
Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
Volume 14 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

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Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
Volume 14												
Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
Volume 14												
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Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
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Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
Volume 14 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
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Fast Fourier Transformation
use Fast Fourier Transform

Fasteners

1420		202	813						1419

Fatigue Life

10	111	102	103	174	105	176	27	178	189
150	471	472	173	184	175	476	197	188	359
210	481	1232	183	474	185	566	477	328	579
250	631	1262	593	504	475	1076	617	368	629
270	931	1412	813	1014	605	1266	1007	478	709
290	1521	1522	1263	1084	925	1416	1267	1268	739
480	1781	1752	1513	1264	1265	1516	1397	1518	959
960	2251	1782	1523	1514	1345	1526	1437	1948	1079
1020	2441	2002	1783	1524	1385	1656	1517	1998	1379
1160	2561	2032	2003	1714	1515	1676	1527	2158	1519
1420	2641	2162	2093	2074	1525	2006	2107	2248	1569
1520		2422	2363	2284	1755	2246	2247	2328	1689
1690			2373	2444	1925	2326	2237		1929
1750			2443		2005	2356			1999
2000						2436			2159
2250						2516			2249
2440						2566			2329
2500									2499
2560									

Fatigue (Materials)

480	481		883	2434	395	186	2437	878	879
880	1081		2433		2435			2438	1729
1080	2371								2439

Fatigue Strength
use Fatigue Life

Fatigue Tests

880	181	882	473	884		1926	177	1078	469
980	881	2162	833	1784		2556	1077	1398	479
2320	2001	2252		2374				2158	
				2434					

Fault Detection
use Failure Detection

Fiber Composites

440	221	2642	1263	1874	905	2006	1927	988	899
1710	1961				2355				
2610	2441								

Fiberglass

									899

Fiber Optics

2030									

Fibers

			1513						

Finite Difference Method

						1746	2467		

Finite Difference Technique

1740		1552	763		145			688	1209
									1709

Finite Difference Theory
use Finite Difference Technique

Finite Element Technique

220	221	382	93	114	145	366	237	108	579
280	241	522	133	214	215	1556	667	468	829
520	321	802	223	534	645	1566	997	528	1209
530	521	942	373	834	915	1836	1017	798	1409
540	621	1102	453	1044	1435	1936	1557	1288	1419
640	631	1152	523	1154	1455	2036	2367	1708	1529
1010	751	1312	743	1384	1545	2056		1738	2499
1100	861	1822	793	1544	1585	2186		2008	
1220	1111	1872	1313	1704	1625	2276		2068	
1270	1691	2282	1673	1914	1865	2496		2578	
1320	1711	2682	1833	2314	1935			2598	
1370	1831		1903	2464					
1740	2481		1993	2514					
1830			2473	2674					
2270			2493						
2370									
2380									
2510									

Finite Strip Method

	131	1482					2177	168	

Flanges

					1605				

Flexibility Coefficients

		2372							

Flexible Couplings

		1682					367		

Flexible Foundations

20		22				946			
750									

Flexible Rotors

750		2	3		255	206	2057	2458	909
1810		1922							2029
									2059

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
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Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
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Noise Propagation
use Sound Propagation

Noise Reduction

50	31	592	53	144	75	66	57	28	29
550	541	862	573	334	345	156	587	88	309
570	591	972	773	344	425	366	747	308	569
590	691	1062	843	784	795	766	937	588	589
630	971	1492	973	844	985	966	967	618	679
1230	1061	1612	1163	984	1165	976	977	698	939
1360	1491	2212	1243	1944	1635	1236	997	938	999
1700	1631	2332	1573	2274	1855	1636	1137	988	1059
1910	2101		2063	2284	2355	2206	1157	1028	1069
2210	2331		2153	2504	2415	2316	1177	1058	1129
2520	2521		2523	2534	2555	2496	1327	1638	1349
2640			2683	2684	2615		1607	2208	1619
							1637		1879
							1847		2209
							1957		2519
							2097		2609
							2207		
							2327		
							2407		
							2417		
							2487		
							2617		

Noise Shielding

							1137		

Noise Source Identification

1970	2651	562	2613			66			1399
2070		1802				266			1869
		1972							1879
		2022							
		2612							

Noise Tolerance

					75	76			
						2136			

Noise Transmission

							2327		839
							2537		
							2627		

Nonconservative Forces

						1446			

Noncontacting Probes
use Proximity Probes

Nondestructive Testing
use Nondestructive Tests

Nondestructive Tests

500	1331	902	503	1334	1335	1096	727	248	199
1130	1581	1332	903			1786	1797	1578	499
1580		1582	1333						1579
			1963						

Nonlinear Analysis
use Nonlinear Theories

Nonlinear Damping

								1678	1679

Nonlinear Response

	1011	1012			1705				
		2672			2055				

Nonlinear Stiffness

								1678	1679

Nonlinear Systems

		742	2273	2674					2269
		1302							

Nonlinear Theories

		872		1704	1935		1817	1548	
					2565			2578	
					2575				

Nonlinear Vibration

1450					2035	1456		2038	1269

Nonparametric Identification Technique

			1563						

Normal Density Functions

						916			

Normal Modes

	2271				1485	626	2117		
						2476			

Nozzles

	1741	1892							

Nuclear Explosion Detection

				454					

Nuclear Explosion Effects

	1321	1322	863						
			1323						

Nuclear Explosions

700					445	746			2219
						1486			2419

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Volume 14												
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Volume 14												
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Tanks (Containers)
670 402 403 1154 1219

Taxiing Effects
282 65

T-Beams
117

Temperature Effects
1041 1192 254 675 1047 1279
2592 2144

Test Data
use Experimental Data

Test Equipment and Instrumentation
181 252 904 2026 2017 248 469
251 492 1798 1799
1532
2262

Test Facilities
900 201 722 493 334 1286 1539
901 2022 1093 494
1091

Text Fixtures
use Test Facilities

Test Instrumentation
use Test Equipment and Instrumentation

Test Models
501 974
2661

Test Stands
201

Testing Apparatus
use Test Equipment and Instrumentation

Testing Equipment
use Test Equipment and Instrumentation

Testing Instrumentation
use Test Equipment and Instrumentation

Testing Machines
use Test Equipment and Instrumentation

Testing Techniques
200 1281 302 1283 1094 405 496 497 248 199
840 782 1843 1284 495 726 787 598 499
1090 902 1873 1784 905 1787 728 779
1850 1282 2263 1844 2135 978 1089
2340 1532 2114 1798 1789
2122 2454

Textile Looms
894 1028 1129

Textile Spindles
use Spindles

Textiles
2424

Thermal Effects
1385

Thermal Excitation
use Temperature Effects

Thermal Insulation
1173

Thermal Protection Systems (Spacecraft)
2541

Thermoelasticity
190

Thermoviscoplastic Media
1981

Thickness Effects
use Geometric Effects

Thomson-Baron Formula
1755

Three Dimensional Problems
2281

Thrust Bearings
1410 1413 2155 1188

Tiles
1541 732 2123 2124 1896 1897
2541

Time-Dependent Excitation
2464 1015 1937

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Volume 14												
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Transformers
1795 1236
2206

Transient Excitation
950 1201 32 1473 1456 1347
1422

Transient Response
1030 191 572 653 404 1955 216 147 138 119
1200 651 712 2393 256 217 218 699
1350 1711 822 2423 1716 537 238 779
1710 1991 1832 2463 1747 728 1209
2290 2321 1902 2007 1598 1849
2481 1748 2009
2569

Transient Sound
1056

Translational Response
940

Transmissibility
use Transmissivity

Transmission Lines
2381 373 2566

Transmission Systems
512

Transportation Systems
use Transportation or Transportation Vehicles

Transportation Vehicles
1383 46 1869

Transverse Shear Deformation Effects
130 101 682 2393 1204 115 1706 128 659
620 1211 2552 2593 645 2586 829
1710 655 1019
2610 1045
2205

Trapezoidal Bodies
658

Trees (Plants)
291 1487 859

Triangular Bodies
825 658

Truck Tires
355
1185

Trucks
900 1901 344 965 966 967 968 299
934 976 969
2524 1386 1329
2546 1869
1909

Trusses
270

Tube Arrays
140 1471 1472 673 1464 1026 1467 208 1439
1470 2602 1463 1734 1466 1438 1469
2200 2603 1736 1468 2199

Tubes
420 421 1732 1733 674 835 1046 407 418 139
1731 1734 1465 1736 1097 1098 419
1735

Tuned Dampers
796

Tuned Frequencies
164

Tuning
2360 803 1534 348 799
1894

Tunnels
1330 952 2629

Turbine Blades
800 801 102 543 544 625 626 1917 2558 259
1000 1001 2363 2364 1675 2559

Turbine Components
730 1191 2265 738 559

Turbine Engines
543 104 1187 259
544

Turbines
510 2291 642 2283 1846 288 239
2436 1408
1918

Abstract Numbers:	1-254	255-554	555-746	747-927	928-1131	1132-1335	1336-1582	1583-1844	1845-2056	2057-2284	2285-2489	2490-2684
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Vortex-Induced Vibration

1380				1474			2427	1428	1379
1560								1508	
1990									

Vortex Noise

					2295				

Vortex Shedding

170				434		2566		818	819
1470				1014					1359
				1644					1439
									1699

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Walls

150	1051		423	424	175	146	987	148	149
840	2521		273	1234	2205	836	1477	858	839
1480	2611		2403	1744		2676		1048	1479
				2404				1478	1959
								2508	

Wankel Engines

							2157		

Water

						1246			

Water Hammer

		142	143	1984					

Water Waves

290	301	52	223	304	955	306			269
960	781	1562		514	1255	1016			329
	2471			994		1426			

Wave Diffraction

660	431	1242	223	1484	2475	1216		1558	1969
2350	551	2422	1543	2474		1306			2469
			1983						2629
			2413						
			2473						
			2673						

Wave Equation

2470	871			1294			1947		

Wave Forces

1640	1641	1642	1643			1646	1867	1868	1649
	2671	1942				2516			2099
									2319

Wave Generation

	1281								

Wave Number

use Frequency

Wave Propagation

430	161	422	223	404	845	116	1207	428	419
690	431	1692	453	864	1015	846	1277	1308	429
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28 - Mar 4 SAE Congress & Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1983

21-23 NOISE-CON 83 [Institute of Noise Control Engineering] Cambridge, MA *(NOISE-CON 83, Massachusetts Inst. of Tech., Inst. Information Services, 77 Massachusetts Ave., Cambridge, MA 02139 - (617) 253-1703)*

28-31 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

APRIL 1983

18-20 Materials Conference [ASME] Albany, NY *(ASME Hqs.)*

18-21 Institute of Environmental Sciences' 29th Annual Technical Meeting [IES] Los Angeles, CA *(IES, 940 E. Northwest Highway, Mount Prospect, IL 60056 - (312) 255-1561)*

21-22 14th Annual Modeling and Simulation Conference [Univ. of Pittsburgh] Pittsburgh, PA *(William G. Vogt, Modeling and Simulation Conf., 348 Benedum Engineering Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)*

MAY 1983

9-13 Acoustical Society of America, Spring Meeting [ASA] Cincinnati, OH *(ASA Hqs.)*

9-13 Symposium on Interaction of Non-Nuclear Munitions with Structures [U.S. Air Force] Colorado Springs, CO *(Dr. C.A. Ross, P.O. Box 1918, Eglin AFB, Florida 32542 - (904) 882-5614)*

17-19 Fifth Metal Matrix Composites Technology Conference [Office of the Undersecretary of Defense for Research and Engineering] Naval Surface Weapons Center, Silver Spring, MD *(MMCIAC - Kaman Tempo, P.O. Drawer QQ, Santa Barbara, CA 93102 - (805) 963-6455/6497)*

JUNE 1983

6-10 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

20-22 Applied Mechanics, Bioengineering & Fluids Engineering Conference [ASME] Houston, TX *(ASME Hqs.)*

JULY 1983

11-13 13th Intersociety Conference on Environmental Systems [SAE] San Francisco, CA *(SAE Hqs.)*

AUGUST 1983

8-11 Computer Engineering Conference and Exhibit [ASME] Chicago, IL *(ASME Hqs.)*

8-11 West Coast International Meeting [SAE] Vancouver, B.C. *(SAE Hqs.)*

SEPTEMBER 1983

11-13 Petroleum Workshop and Conference [ASME] Tulsa, OK *(ASME Hqs.)*

11-14 Design Engineering Technical Conference [ASME] Dearborn, MI *(ASME Hqs.)*

12-15 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

14-16 International Symposium on Structural Crashworthiness [University of Liverpool] Liverpool, UK *(Prof. Norman Jones, Dept. of Mech. Engrg., The Univ. of Liverpool, P.O. Box 147, Liverpool L69 3BX, England)*

25-29 Power Generation Conference [ASME] Indianapolis, IN *(ASME Hqs.)*

OCTOBER 1983

17-19 Stapp Car Crash Conference [SAE] San Diego, CA *(SAE Hqs.)*

17-20 Lubrication Conference [ASME] Hartford, CT *(ASME Hqs.)*

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AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chic[illegible] Ave.
Evans[illegible] 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

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PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> **Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].**
>
> **Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .**

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
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- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
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A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addision-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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